- SWMU X-735 groundwater from the Gallia aquifer: ingestion by the on-site worker under future use conditions. The inorganic compounds contributing to the HI of 2 are arsenic, chromium, fluoride, nickel, and vanadium.

- SWMU NEDD soil: direct contact with soil by the on-site resident under future use conditions. The inorganic compounds contributing to the HI of 2 are arsenic, chromium and vanadium.

The endpoints of toxicity upon which the RfD is based for the inorganic compounds and Aroclors that cumulatively result in HIs greater than one are presented below.

Chemical	Endpoint upon which the RfD is based
PCBs (Aroclors)	RfDs for Aroclor-1260 and -1254 have not been derived by U.S. EPA; the assessment performed here was based on the RfD for Aroclor-1016, for which an RfD has been established based on reproductive effects (reduced birth weight) in the monkey.
Antimony	Reduced lifespan and altered blood glucose and cholesterol levels
Arsenic	Skin lesions (keratosis and hyperpigmentation)
Barium	Increased blood pressure in humans
Cadmium	Renal damage (proteinuria) in humans
Chromium	No effects were observed in the one-year drinking water study upon which the RfD was based.
Fluoride	Dental fluorosis in humans
Manganese	Central nervous system (CNS) effects (including weakness/fatigue, gait disturbances, tremors, and dystonia)
Nickel	Decreased body and organ weights

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Vanadium	No effects were observed in the lifetime drinking water study upon which the RfD was based.
Zinc	Blood chemistry

Because the targets for toxicity of the above inorganic compounds and Aroclors are dissimilar, summation of the HQs associated with these compounds may be inappropriate. Therefore, exposures associated with the SWMUs and exposure pathways identified above (with cumulative HIs of one or greater) are not anticipated to result in adverse noncancer health effects.

Carcinogen Weight-of-Evidence Classification

As indicated above, one limitation to the procedure for summing cancer risks for multiple chemicals is that the procedure gives as much weight to chemicals assigned to class B (probable human carcinogens) or C (possible human carcinogens) as to class A carcinogens (known human carcinogens). For class C carcinogens, for which there is limited evidence of carcinogenicity in animals and inadequate or lack of human data, the evidence that the chemical is a human carcinogen is the weakest.

Nine chemicals detected in Quadrant IV media at PORTS are class C carcinogens. These are beta-BHC, chloromethane, 1,1-dichloroethane, 1,1-dichloroethene, 2-methylphenol (o-cresol), 3-methylphenol (m-cresol), 4-methylphenol (p-cresol), 1,1,2,2-tetrachloroethane, and 1,1,2-trichloroethane. Additionally, U.S. EPA has not adopted a final position on the weight-of-evidence classification for trichloroethene (see Appendix H.5).

A review was performed of potential risks for each SWMU to determine the extent to which class C carcinogens and trichloroethene (with no classification) contribute to overall risk. Only 1,1-dichloroethene, 1,1,2,2-tetrachloroethane, and trichloroethene present risks in excess of 10^{-6} in any of the Quadrant IV SWMUs. In groundwater (Gallia aquifer) from the X-333 unit, potential risks posed by 1,1-dichloroethene and trichloroethene under the future on-site residential scenario comprise approximately 90 percent of the total risk (9×10^{-5}) associated with organic chemicals in groundwater. In groundwater from the Gallia aquifer at the X-734 unit, potential risks posed by trichloroethene under the future on-site residential scenario comprise approximately 49 percent of the total risk (2×10^{-5}) associated with organic chemicals in groundwater. Finally, in groundwater (Berea aquifer) from SWMU NDD, potential risks posed by 1,1,2,2-tetrachloroethane under the future on-site residential scenario comprise about 73 percent of the total risk (7×10^{-6}) associated with organic chemicals.

Given the significance of risks posed by class C carcinogens (and trichloroethene, for which a weight-of-evidence classification has not been determined), it may be appropriate for risk managers to consider the uncertainty in the cancer assessments for organic constituents in groundwater from the X-333, X-734, and NDD units in the development of remedial alternatives.

6.5.4.3 Summary of Uncertainties

The majority of uncertainties discussed above are likely to lead to overestimation of potential risks associated with constituents present at PORTS. Because the assumptions and variable values used in the BRA about which there is associated uncertainty are not independent, and because it is difficult to ascribe to most uncertainties a magnitude by which potential health risk may be under or overestimated, an overall estimate of the extent

to which actual potential health risk may be overstated cannot be developed. In general, actual risks, if any, could be several orders of magnitude less than presented here.

As stated previously, risks estimated using the methods of risk assessment prescribed by regulatory agencies are not actuarial. Given the uncertainties in risk assessment, the risk estimates derived herein may be of greatest value for establishing relative risk, i.e., by comparison to other risks derived using similar risk assessment methods and similarly conservative assumptions.

6.6 Preliminary Ecological Risk Assessment (PERA)

6.6.1 Objectives and Scope

A "preliminary ecological risk assessment" was conducted for Quadrant IV following the methodology developed by Suter (1990) for the Environmental Sciences Division (ESD) of the Oak Ridge National Laboratory (ORNL). This methodology, which was further developed for PORTS by Kramel, Hull and Bonczek of ORNL and described in the Quadrant IV RFI Work Plan (Geraghty & Miller, Inc., 1992a), was used as the principal guidance for preparing the PERA for Quadrant IV. The same approach was used to prepare the PERA for Quadrants I, II, and III.

The ecological risk assessment process, as developed by ORNL and described in the Quadrant IV Work Plan (Geraghty & Miller, Inc., 1992a), is a two step procedure. The first step is to conduct a separate PERA for each quadrant. The PERA is conducted on a quadrant-wide, watershed, and solid waste management unit (SWMU) level. This is ideally followed by a facility-wide Baseline Ecological Risk Assessment (BERA). The purposes of a PERA are: (1) to compile existing fate, exposure and ecotoxicity information (including that collected during the RFI); and (2) to evaluate this information, using a

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screening process, to focus the facility-wide BERA. Specifically, the PERA identifies and screens potential constituents of concern (COCs) for ecological risks for each SWMU. Further, the PERA identifies the watersheds within the quadrant and determines which SWMUs are located in each watershed. Finally, the PERA presents an overview of the biotic community types within the quadrant. To accomplish the PERA, screening benchmarks for ecological effects are developed for each chemical constituent in each environmental medium evaluated during the RFI (i.e., sediment, surface water, and soil).

The objective of this section is to present the results of a PERA performed for Quadrant IV at the PORTS facility. The remainder of Section 6.6 is organized as follows:

Section 6.6.2. Site characterization of PORTS and Quadrant IV. This section describes the physical characteristics of the area; source units/SWMUs; and integrator units (i.e., watersheds).

Section 6.6.3. Ecological characterization of Quadrant IV. Identification and characterization of local biotic communities and special resources are discussed.

Section 6.6.4. Identification of constituents of concern (COCs) and sources of contamination. This section provides a description of chemical data, establishment of RME concentrations, and a discussion of COCs relative to SWMUs and watersheds.

Section 6.6.5. Environmental fate of COCs.

Section 6.6.6. Derivation of screening benchmarks.

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Section 6.6.7. Comparison of COCs with screening benchmarks. Comparison of hazard benchmarks to measured levels in each environmental medium to identify relative risk levels and categorization of COCs, SWMUs and watersheds based on screening benchmarks and relative risk levels.

Section 6.6.8. Conclusions

6.6.2 Site Characterization of PORTS and Quadrant IV

PORTS is located in south-central Ohio (Pike County), approximately one mile east of the Scioto River. The facility occupies approximately 6.3 square miles in a predominantly rural area. The overall size of the area, diversity of habitat types present, and rural surroundings allow a considerable diversity of fish and wildlife species to inhabit the site. The nearest town is Piketon (approximately 5 miles north), which had a population of 1900 in 1986 (Energy Systems, 1990).

The site and its immediate environs are located within a relatively level, broad valley that is oriented north-south and is approximately 120 feet higher in elevation than the Scioto River. There are low lying hills east and west of the facility that contain drainage areas or other small valleys. Within a 5-mile radius of the facility, land use is divided between farmland (24,430 acres including cropland, pasture and commercial woodlots) and forests (24,416 acres) with some hills and terraces utilized for cattle pasture. Within this same area, only 206 acres are classified as urban (Energy Systems, 1990).

The following description of Quadrant IV is based on a site visit, examination of topographic maps, the "Quadrant IV Description of Current Conditions" (Geraghty & Miller, 1992f) and the "Baseline Ecological Risk Assessment Workplan" for PORTS (U.S.

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DOE, 1993). Quadrant IV covers the northern section of the PORTS site and is approximately 1,780 acres in size. Quadrant IV is primarily flat with hills to the west, north and east following the boundary of the quadrant. Figure 6.2 shows the land use in Quadrant IV at PORTS. The southern portion of Quadrant IV consists primarily of an industrial area (buildings, pavements, railroad yards, etc.). Additional industrial areas (landfills) are found in the western and northcentral portions of the quadrant. Approximately 21 percent of the land area in Quadrant IV is industrial in nature. Most of the land in the central portion of Quadrant IV is grass-covered and has few shrubs and trees. Grassy areas comprise approximately 29 percent of the total land area of Quadrant IV. Forest or wooded areas account for 46 percent of the land in Quadrant IV. The eastern and western portions are forested, as is the riparian zone of Little Beaver Creek, which flows through the quadrant.

The largest aquatic resource associated with the PORTS facility is Little Beaver Creek, which is located almost entirely within Quadrant IV. This stream flows in a northwesterly direction through the quadrant. Little Beaver Creek eventually discharges off-site to Big Beaver Creek, which eventually empties into the Scioto River. Although Little Beaver Creek is located in Quadrant IV, it was addressed previously in the Quadrant II PERA and has also been addressed in the BERA. Therefore, Little Beaver Creek is not considered further in the Quadrant IV PERA. Other significant water bodies located within Quadrant IV boundaries include two drainage ditches (the Northeast Drainage Ditch, or NEDD, and the North Drainage Ditch, or NDD) that flow into Little Beaver Creek, one holding pond (X-230L), one large sludge lagoon (X-611B) and three smaller lagoons (X-611A) that are connected to the ditches and/or the creek. Approximately 4 percent of the land area within Quadrant IV is water.

6.6.2.1 Identification of SWMUs Considered in the PERA

Section 4.0 of the RFI provides details on the 27 SWMUs that have been identified in Quadrant IV; 22 of these SWMUs are considered in this PERA (Table 6.332). SWMUs RCW, STSW, and SASW were not considered because they are dispersed throughout the quadrant; data from individual sample points were assigned to other SWMUs, where possible, and were included in the overall evaluation of the quadrant. SWMUs X-344A and X-744W were not considered because all samples were taken from groundwater or deep (greater than two feet) soils (see below).

There are several differences in the way the available RFI data have been used in the PERA as compared with the human health baseline risk assessment (BRA):

- Only soil data collected at depths of zero to two feet were used in the PERA. Soil data from samples deeper than this were not considered relevant since there is little or no exposure to ecological receptors. In the human health BRA, soil data from 0 to 10 feet were evaluated.

- Groundwater samples were not considered in this PERA because: (1) it is assumed that the groundwater is hydrologically linked to the surface waters, which have already been sampled and addressed in the PERA; and (2) groundwater, which is present on average across the PORTS site at a depth of 16 feet, is not generally recognized as a viable exposure pathway for biota beyond its link to surface water. Surface-water data are considered in the PERA. Future migration of groundwater plumes and their discharge to surface water would be considered in a more rigorous assessment, such as a BERA. Groundwater data were considered in the human health BRA.

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- Data likely representative of possible localized contamination (i.e., "hot spots") were included in the quadrant-wide data set for the PERA, but were not included in the quadrant-wide data set for the human health BRA (see Section 6.2.3) Because the PERA is a screening level assessment, "hot spots" were included in order to be conservative.

6.6.2.2 Identification of Integrator Units (Watersheds)

According to U.S. DOE (1993), virtually all of Quadrant IV can be considered one watershed. Water resources for Quadrant IV are presented in Figure 6.3. All of the surface-water runoff in Quadrant IV drains toward Little Beaver Creek. Little Beaver Creek eventually empties into Big Beaver Creek approximately three-quarters of a mile off-site from the northwestern boundary of the facility. Big Beaver Creek empties into the Scioto River approximately two miles from the facility.

Little Beaver Creek is the major water system located within Quadrant IV. The creek bisects the quadrant from the southeast corner to the northwest boundary. Several drainage ditches also located within the quadrant empty directly into Little Beaver Creek; these include the North Drainage Ditch (NDD) and the Northeast Drainage Ditch (NEDD), both of which originate from the southern portion of the quadrant just north of Perimeter Road.

6.6.3 Ecological Characterization of Quadrant IV

Most of the information presented in this section is not specific to Quadrant IV. Quadrant-specific information was included when available.

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6.6.3.1 Wetlands

U.S. DOE (1993) states that site-wide, "...several small wetland areas have developed around holding ponds and in ditch lines." A wetlands survey was conducted at the PORTS facility in 1994 by Adams and Butler, and is included in Appendix H.8.

6.6.3.2 Vegetative Cover

The southern portion of the quadrant (inside the Perimeter Road) is comprised primarily of buildings, roads, railroad yards and other industrial areas. There is limited vegetation except for maintained lawns; much of the area is covered with pavement or crushed rock (in railroad yards).

The portion of Quadrant IV outside Perimeter Road contains old fields, pasture land and forest. According to Kornegay et al. (1991), as cited in U.S. DOE (1993), all of the forests on the facility are second growth and the dominant forest cover type is oak-hickory forest. Other species present include: maple, ash, pine and sycamore. The U.S. DOE also lists the following subcanopy species: shining sumac, poison sumac, poison ivy, and blackberry.

6.6.3.3 Terrestrial Wildlife

An extensive terrestrial wildlife survey of the PORTS reservation was conducted in the mid-1970s (Battelle, 1976a, as cited in U.S. DOE, 1993). Based on this survey, the wildlife on the PORTS site are typical of those normally found in south-central Ohio. Quadrant IV and adjacent areas provide several habitat types including open fields, deciduous wooded areas, small ponds, and intermittent drainage ditches/creeks. However,

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the relatively sparse cover, and high human activity, and fencing inside Perimeter Road provides limited habitat for most wildlife species within this industrial area.

6.6.3.3.1 Mammals

Gottschang (1981) lists the species of mammals found in Pike County and U.S. DOE (1993) summarizes information on fauna-sightings at PORTS. The table below lists 49 species that have geographical ranges that include the PORTS facility. Also noted in the table are species whose presence in Pike County have been confirmed by hunting and trapping records of the Ohio Department of Natural Resources (ODNR) Division of Wildlife. Pike County ranks 85th out of 88 (third from the lowest) among Ohio counties in overall forbearer harvest and 35th in deer harvest. Those species that typically inhabit areas with significant water resources (e.g., beaver, muskrat, and mink) are likely to be found in Quadrant IV due to the presence of Little Beaver Creek.

Species of Mammals Identified in Pike County, Ohio

Classification	Species[1]
Marsupials	Virginia opossum[2,3]
Insectivores	masked shrew, smoky shrew, short-tailed shrew[3], least shrew, hairy-tailed mole, eastern mole
Bats	little brown bat, Keen's bat, Indiana bat, silver-haired bat, eastern pipistrelle, big brown bat, red bat, hoary bat, evening bat
Rabbits and Hares	Eastern cottontail[3]
Rodents	Eastern chipmunk[3], woodchuck[3], striped gopher, gray squirrel[3], fox squirrel[3], red squirrel, southern flying squirrel, beaver[2], eastern harvest mouse, deer mouse, white-footed mouse[3], pack rat, field mouse, prairie vole, pine mouse, muskrat[2], southern bog lemming, brown rat, house mouse, meadow jumping mouse
Herbivores	white-tailed deer[2,3]

Species of Mammals Identified in Pike County, Ohio	
Classification	**Species[1]**
Carnivores	coyote, red fox[2], gray fox[2], raccoon[2], least weasel, long-tailed weasel[2,3], mink[2], badger, striped skunk

[1] Obtained from Gottschang (1981).
[2] The presence of this species in Pike County was confirmed from 1985-86 trapping records obtained from the Ohio Department of Natural Resources.
[3] Listed in U.S. DOE (1993) as having been observed on the PORTS reservation.

6.6.3.3.2 Birds

Peterjohn and Rice (1991) list 109 species of birds with confirmed, probable, or possible breeding records in Pike County, Ohio; this list is presented in the following table. According to U.S. DOE (Battelle, 1976a, as cited in U.S. DOE, 1993), 116 avian species have been observed at the PORTS facility including both year-round residents and migratory species.

Species of Breeding Birds Identified in Pike County, OH (Peterjohn and Rice, 1991)		
Classification	**Breeding Status**	**Species**
Birds of prey	Confirmed	broad-winged hawk, red-tailed hawk, American kestrel, great horned owl
	Probable	sharp-shinned hawk, Cooper's hawk, red-shouldered hawk, eastern screech-owl, barred owl
	Possible	turkey vulture
Water birds	Confirmed	green-backed heron, wood duck, mallard, belted kingfisher, killdeer
	Probable	--
	Possible	--

Species of Breeding Birds Identified in Pike County, OH (Peterjohn and Rice, 1991)		
Classification	**Breeding Status**	**Species**
Upland birds	Confirmed	ruffed grouse, wild turkey[1], northern bobwhite, rock dove, mourning dove, chuck-will's-widow, whip-poor-will, chimney swift, red-bellied woodpecker, downy woodpecker, hairy woodpecker, northern flicker, pileated woodpecker, eastern wood-pewee, acadian flycatcher, eastern phoebe, great crested flycatcher, eastern kingbird, purple martin, tree swallow, northern rough-winged swallow, bank swallow, barn swallow, blue jay, American crow, Carolina chickadee, tufted titmouse, white-breasted nuthatch, Carolina wren, Bewick's wren, house wren, blue-gray gnatcatcher, eastern bluebird, wood thrush, American robin, gray catbird, northern mockingbird, brown thrasher, cedar waxwing, European starling, white-eyed vireo, yellow-throated vireo, warbling vireo, red-eyed vireo, blue-winged warbler, yellow warbler, yellow-throated warbler, prairie warbler, cerulean warbler, black-and-white warbler, American redstart, worm-eating warbler, ovenbird, Louisiana waterthrush, Kentucky warbler, common yellowthroat, hooded warbler, yellow-breasted chat, summer tanager, scarlet tanager, northern cardinal, indigo bunting, rufous-sided towhee, chipping sparrow, field sparrow, grasshopper sparrow, Henslow's sparrow, song sparrow, red-winged blackbird, eastern meadowlark, common grackle, northern oriole, American goldfinch, house sparrow
	Probable	American woodcock, black-billed cuckoo, yellow-billed cuckoo, ruby-throated hummingbird, red-headed woodpecker, willow flycatcher, horned lark, northern parula, pine warbler, rose-breasted grosbeak, blue grosbeak, dickcissel, vesper sparrow, savannah sparrow, bobolink, brown-headed cowbird, orchard oriole, house finch, common nighthawk
	Possible	prothonotary warbler
[1] The presence of this species in Pike County was confirmed from 1989-90 hunting records obtained from the Ohio Department of Natural Resources.		

6.6.3.4 Reptiles and Amphibians

The U.S. DOE (1993) states that 28 species of reptiles and 30 species of amphibians have ranges that include the PORTS facility; the most common reptiles are the Eastern box turtle, black rat snake, and Northern black racer. In addition, the following reptiles have been observed on the PORTS facility (Battelle, 1976a, as cited in U.S. DOE, 1993):

snapping turtle; map turtle; midland painted turtle; Eastern spiny softshell turtle; Northern water snake; Eastern garter snake; and the Eastern hognose snake. Among the most common amphibians for this region of Ohio are the American toad, and Northern dusky salamander. In addition, the following amphibians have been observed on the PORTS reservation (Battelle 1976, as cited in U.S. DOE, 1993): bullfrog; Northern leopard frog; Northern spring peeper; and Fowler's toad.

6.6.3.5 Insects

Battelle (1976, as cited in U.S. DOE, 1993) reports collecting approximately 500 species of insects in various habitats at the PORTS facility. The following insect orders were the most prevalent: Homoptera (cicadas, aphids, scale insects), Hymenoptera (ants, wasps, bees), Diptera (flies, gnats, mosquitoes), and Coleoptera (beetles). U.S. DOE (1993) concluded the following:

> Greatest numbers of insects and highest diversity indexes were found in pine forests, old fields with diverse herbaceous vegetation, and hardwood forests with dense understory. Open forest areas tended to have intermediate diversity indexes and numbers of insects. Low diversity indexes and low numbers of insects were found in dense stands of fescue, sparsely vegetated fields, and grazed woodlots. One herbaceous fencerow was sampled and was found to have high numbers of insects but a low diversity index.

6.6.3.6 Aquatic Organisms

Numerous species of fish and aquatic invertebrates inhabit the waters of south-central Ohio. The U.S. DOE (1993) cites Kornegay et al. (1991) as reporting 58 species of fish present in streams in the immediate vicinity of the PORTS facility. Trautman (1981) has compiled information on the species of fish that inhabit specific bodies of water, including fish in the Scioto River drainage in Pike County.

As part of the RFI for Quadrant II, a qualitative survey of fish and benthic macroinvertebrate species was conducted (Geraghty & Miller, 1992c). A total of 22 species of fish were collected from three sampling stations along Little Beaver Creek; these sampling stations were all located with the PORTS reservation, and two of the three within Quadrant IV (Table 6.333). Table 6.334 lists macroinvertebrate taxa observed in Little Beaver Creek during the same survey.

It is unlikely that NDD, NEDD, their associated holding ponds, or sludge lagoons would contain significant numbers of fish because of intermittent flows, shallow depths and related habitat limitations. However, habitation by macroinvertebrates, reptiles and amphibians in these areas is possible.

6.6.3.7 Threatened and Endangered Species

Appendix H.9 contains a copy of a document entitled "Technical Memorandum for Threatened and Endangered Species Habitat Survey." U.S. DOE (1993) discusses other possible threatened or endangered species that may be present in or around the facility. These species are listed in Table 6.335. This information on threatened and endangered species will be useful in the identification of indicator species for consideration in

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quantifying ecological risk at PORTS during a more detailed assessment such as a facility-wide BERA.

6.6.4 Identification of Constituents of Concern and Potential Sources of Contamination

This section provides a qualitative discussion of chemical concentrations in Quadrant IV media. Chemicals found at (RME) concentrations below preliminary background are dropped from the assessment (preliminary background data are only available for inorganics in soil). In addition, tables are provided for each SWMU with summary statistics that are used in Section 6.6.7 for comparison to screening benchmarks. The location of quadrant-wide maximum concentrations and COCs unique to a SWMU in a given environmental medium are presented. All sample points in Quadrant IV were assigned to the same watershed.

6.6.4.1 Constituents of Concern (COCs)

Soil, sediment, surface-water and groundwater samples have been collected from in and around the SWMUs in Quadrant IV and analyzed for various organic, inorganic, and radionuclide COCs. The analyses performed on each sample are discussed in Chapter 4.0 and noted in Section 6.6.4.3. The numbers of samples by environmental medium for each SWMU evaluated in the PERA are presented in Table 6.336.

Tables 6.337 and 6.338 present the calculated quadrant-wide RME concentrations (by environmental medium) for each of the constituents detected in the quadrant. For each constituent, the RME concentration is represented by either the 95 percent upper confidence limit (UCL) of the quadrant-wide mean concentration of the log-normally transformed data or by the maximum reported value, whichever value is less (see Section 6.3.4 for the details on calculating RME concentrations). These RME values are compared to adverse

effect screening benchmarks, established for each of the environmental media, to identify potential risks within the quadrant or watershed. For the analysis of individual SWMUs, maximum detected concentrations were used as the RME concentrations because of the relatively small data sets for each of the SWMUs.

A total of 26 inorganic COCs were detected in at least one environmental medium (sediment, surface water, and soil [0-2 feet depth only]) and 11 (arsenic, barium, beryllium, cadmium, chromium, cobalt, fluoride, lead, nickel, vanadium, and zinc) were detected in all three environmental media (Table 6.337). Twenty-five of the 26 inorganic COCs were detected in sediment, 23 were detected in soil and 11 of 26 were detected in surface water. Antimony, selenium and silver were only detected in sediment; lithium was only detected in soil.

A total of 51 organic COCs were detected in sediment, surface-water, or soil samples collected in Quadrant IV (Table 6.338). Most (41) of the 51 organic COCs were detected in soil samples and about half (25) were detected in sediment samples. Eighteen of the organic COCs were detected in surface-water samples. 4-Chlorophenyl-phenyl ether and dieldrin were only detected in sediment. Eight organic COCs were detected only in surface-water samples (alpha-BHC, bromodichloromethane, chloromethane, dibromochloromethane, 2,4-dichlorophenoxyacetic acid [2,4-D], cis-1,2-dichloroethene, 1,4-dioxane, and 2-hexanone). Fourteen organic COCs were detected only in soil (Aroclor-1254, benzene, 4,4'-DDE, 4,4'-DDT, 2,4-dimethylphenol, endrin ketone, ethylbenzene, methoxychlor, 3/4-methylphenol (m&p-cresol), 4-methylphenol (p-cresol), 4-nitroaniline, styrene, 1,2,4-trichlorobenzene, and xylene). Seventeen organic COCs were detected in both sediment and soil but not surface water. Six organic COCs (acenaphthene, dibenzofuran, fluorene, 2-methylnaphthalene, naphthalene and phenanthrene) were detected in all three media.

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As per the approved workplans for Quadrant IV, the radiological parameters for which samples were routinely analyzed included total uranium and technetium. Both technetium and uranium were detected in sediment and soil but not in surface water.

6.6.4.2 Background Levels for COCs

The first step in establishing which chemicals may actually represent an ecological risk in Quadrant IV is to consider natural background levels in the area. As in the human health BRA, consideration of background was based on the tentative background analysis available at the time of the PERA. Tentative background values were available for all inorganic COCs in soils except cyanide, lithium, and thallium.

RME concentrations calculated using the quadrant-wide soil data sets were compared to tentative background levels (Table 6.339). Quadrant-wide RME concentrations for 16 of the 23 inorganic COCs found in soils were below tentative background levels (Categories 1 and 2 in Table 6.339) and were dropped from further analysis in the quadrant-wide PERA.[8] Background levels were not available for three inorganic COCs (cyanide, lithium, and thallium) and these COCs were considered in the quadrant-wide PERA analysis. RME concentrations for four inorganic COCs (calcium, fluoride, magnesium, and sodium) were above tentative background levels and these compounds were also considered in the quadrant-wide PERA analysis.

Among radionuclides, the RME for uranium was above background; a background level does not exist for technetium. Therefore, uranium and technetium were both considered in the PERA quadrant-wide analysis.

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[8]Note that the RME concentration in the quadrant-wide analysis was calculated as the lesser of the 95 ***percent*** upper confidence limit on the mean or the maximum detected value.

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The RME concentration used in the analyses of individual SWMUs was the maximum detected concentration in the given SWMU. Therefore, background levels were compared to maximum detected levels for each inorganic and radionuclide soil COC at a SWMU. When the maximum value was below the background level, the COC was dropped from further analysis in the PERA. Twenty-one of the twenty-three inorganic COCs with background data were included in the SWMU by SWMU analysis of soils; concentrations of aluminum and vanadium were below tentative background in all Quadrant IV SWMUs.

Background data were not available for COCs detected in sediment or surface water. All COCs detected in these environmental media were considered in this PERA.

6.6.4.3 Discussion of COCs by SWMU

The following SWMU by SWMU description of the analytical data indicates which constituents were detected in sediment, surface water, and soil (0 to 2 feet) at each SWMU. Table 6.340 provides a list of those COCs found at a single SWMU, by environmental medium. This table of "unique" COCs facilitates assignment of contamination by a COC to a single SWMU. Tables 6.341 to 6.373 provide SWMU-specific data for all detected COCs by environmental medium.

X-114A Firing Range (X-114A)

One Phase II surface-water sample was taken from X-114A (metals analyses). Eight inorganic COCs were detected in surface water. No Phase I samples were collected. These data are presented in Table 6.341.

Five soil samples were taken from X-114A (three Phase I and two Phase II). Phase I samples were analyzed for lead; Phase II samples were analyzed for metals. Nineteen

inorganic COCs were detected (seven with maximum detections above background). These data are presented in Table 6.342.

X-230J6 Northeast Holding Pond, Monitoring Facility, and Secondary Oil Collection Basin (SOCB) (X-230J6)

Nine sediment samples were taken from X-230J6 (six Phase I and three Phase II). Phase I samples were analyzed for TCL/TAL and RADs; Phase II samples were analyzed for metals. Twenty-four inorganic COCs, 20 organic COCs, and two radionuclides were detected in sediment. These data are presented in Table 6.343.

Six Phase I surface-water samples were taken from X-230J6 (APPIX and RADs analyses). Four inorganic COCs and nine organic COCs were detected in surface water. No Phase II samples were collected. These data are presented in Table 6.344.

X-333 Process Building (X-333)

Fifteen soil samples were taken from X-333 (5 Phase I and 10 Phase II). Phase I samples were analyzed for chromium and zinc and Phase II samples were analyzed for TCL/TAL and RADs, except for one sample which was analyzed for TCL/TAL only. Twenty inorganic COCs (10 with maximum detections above background), 32 organic COCs, and one radionuclide were detected in soil. These data are presented in Table 6.345.

X-334 Transformer Storage and Cleaning Building (X-334)

Four Phase I soil samples were taken from X-334 (TCL/TAL and RADs analyses). Nineteen inorganic COCs (5 with maximum detections above background), 10 organic

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COCs and one radionuclide were detected in soil. No Phase II samples were collected. These data are presented in Table 6.346.

X-342A Feed Vaporization and Fluorine Generation Building; X-342B Fluorine Storage Building; X-342C Waste HF Neutralization Pit (X-342)

One Phase I sediment sample was taken from X-342 (TCL/TAL and RADs analyses). Eighteen inorganic COCs, 14 organic COCs, and two radionuclides were detected in sediment. No Phase II samples were collected. These data are presented in Table 6.347.

One Phase I surface-water sample was taken from X-342 (APPIX and RADs analyses). One inorganic COC was detected in surface water. No Phase II samples were collected. These data are presented in Table 6.348.

X-344C HF Storage Facility and X-344D HF Neutralization Pit (X-344C/D)

Four Phase I sediment samples were taken from X-344C/D (TCL/TAL and RADs analyses). Seventeen inorganic COCs, 20 organic COCs, and two radionuclides were detected in sediment. No Phase II samples were collected. These data are presented in Table 6.349.

Four Phase I surface-water samples were taken from X-344C/D (APPIX and RADs analyses). Three inorganic COCs were detected. No Phase II samples were collected. These data are presented in Table 6.350.

Two Phase I soil samples were taken from X-344C/D (TCL/TAL and RADs analyses). Nineteen inorganic COCs (four with maximum detection above background), three organic COCs, and one radionuclide were detected in soil. No Phase II samples were collected. These data are presented in Table 6.351.

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X-533A Switchyard; X-533B Switch House; X-533C Test and Repair Building; X-533D Oil House and Associated French Drains; X-533E Valve House; X-533H Gas Reclaiming Cart Garage (X-533A)

Seven Phase I soil samples were taken from X-533A (TCL/TAL and RADs analyses). Nineteen inorganic COCs (six with maximum detections above background), seven organic COCs, and one radionuclide were detected in soil. No Phase II samples were collected. These data are presented in Table 6.352.

X-611A North, Middle, and South Lime Sludge Lagoons (X-611A)

Eleven Phase I sediment samples were taken from X-611A (APPIX and RADS analyses). Fourteen inorganic COCs and one radionuclide were detected in sediment. No Phase II samples were collected. These data are presented in Table 6.353.

Two Phase I soil samples were taken from X-611A (chromium and zinc analyses). Both inorganic COCs were detected; neither maximum detection was above background. No Phase II soil samples were collected. These data are presented in Table 6.354.

X-630 Recirculating Water Pump House; X-630-2A Cooling Tower; X-630-2B Cooling Tower; X-630-3 Acid Handling Station (X-630)

Twenty-one Phase I soil samples were taken from X-630. Nine samples were analyzed for chromium and zinc, five were analyzed for TCL/TAL and RADs, and the remaining seven were analyzed for TCL/TAL only. Nineteen inorganic COCs (9 with maximum detections above background), 16 organic COCs, and one radionuclide were detected in soil. No Phase II samples were collected. These data are presented in Table 6.355.

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X-734 Old Sanitary Landfill; X-734A Landfill Utility Building (X-734)

Five sediment samples were taken from X-734 (two Phase I and three Phase II). All samples were analyzed for TCL/TAL and RADs. Eighteen inorganic COCs, 19 organic COCs, and two radionuclides were detected in sediment. These data are presented in Table 6.356.

Five surface-water samples were taken from X-734 (two Phase I and three Phase II). All samples were analyzed for APPIX and RADs. Eight inorganic COCs and two organic COCs were detected in surface water. These data are presented in Table 6.357.

Ten Phase II soil samples were taken from X-734 (TCL/TAL and RADs analyses). Twenty-one inorganic COCs (8 with maximum detections above background), 25 organic COCs, and two radionuclides were detected in soil. No Phase I samples were collected. These data are presented in Table 6.358.

X-735 Sanitary Landfill (X-735)

One Phase I soil sample was taken from X-735 (TCL/TAL analysis). Sixteen inorganic COCs (none with maximum detections above background) were detected in soil. No Phase II samples were collected. These data are presented in Table 6.359.

X-745B Enrichment Process Gas Yard (X-745B)

Eight soil samples were taken from X-745B (five Phase I and three Phase II). Phase I samples were analyzed for TCL/TAL, RADs, chromium, and zinc; Phase II samples were analyzed for SVOCs, PCBs, and RADs. Eighteen inorganic COCs (8 with maximum

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detections above background), 21 organic COCs, and two radionuclides were detected in soil. These data are presented in Table 6.360.

X-745E Northwest International Process Gas Yard (X-745E)

Six Phase I soil samples were taken from X-745E (TAL and RADs analyses). Nineteen inorganic COCs (four with maximum detections above background) and one radionuclide were detected in soil. No Phase II samples were collected. These data are presented in Table 6.361.

X-745F North Process Gas Stockpile Yard (X-745F)

Eight Phase II soil samples were taken from X-745F (SVOCs, PCBs, and RADs analyses). Twenty inorganic COCs (five with maximum detections above background), sixteen organic COCs and one radionuclide were detected in soil. No Phase I samples were collected. These data are presented in Table 6.362.

X-747H Northwest Surplus and Scrap Yard (X-747H)

Twenty soil samples were taken from X-747H (13 Phase I and seven Phase II). Phase I samples were analyzed for TCL/TAL and RADs; three Phase II samples were analyzed for SVOCs and RADs, and four were sampled for RADs only. Nineteen inorganic COCs (8 with maximum detections above background), 20 organic COCs, and two radionuclides were detected in soil. These data are presented in Table 6.363.

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X-752 Hazardous Waste Storage Facility (X-752)

Five Phase I soil samples were taken from X-752 (TCL/TAL and RADs analyses). Nineteen inorganic COCs (six with maximum detections above background), seven organic COCs, and one radionuclide were detected in soil. No Phase II samples were collected. These data are presented in Table 6.364.

Chemical and Petroleum Containment Basins, East of X-533A, and Emergency Containment Tanks (CPCB)

Four Phase II soil samples were taken from CPCB (TCL/TAL and RADs analyses). Nineteen inorganic COCs (4 with maximum detections above background), 14 organic COCs, and one radionuclide were detected in soil. No Phase I samples were collected. These data are presented in Table 6.365.

North Drainage Ditch (NDD); X-230L North Holding Pond; Construction Spoils Area (NDD)

Twenty-five Phase I sediment samples were taken from NDD. Sixteen samples were analyzed for TCL/TAL and RADs; nine samples were analyzed for VOCs, TAL, and RADs. Twenty one inorganic COCs, 20 organic COCs, and two radionuclides were detected in sediment. No Phase II samples were collected. These data are presented in Table 6.366.

Sixteen Phase I surface-water samples were taken from NDD (APPIX and RADs analyses). Four inorganic COCs and eight organic COCs were detected in surface water. No Phase II samples were collected. These data are presented in Table 6.367.

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Ten soil samples were taken from NDD (eight Phase I and two Phase II). Nine samples were analyzed for RADs and one sample was analyzed for VOCs. One organic COC and one radionuclide were detected in soil. These data are presented in Table 6.368.

Northeast Drainage Ditch (NEDD)

Five sediment samples were taken from NEDD (four Phase I and one Phase II). All Phase I samples were analyzed for TCL/TAL and RADs; the Phase II sample was analyzed for SVOCs. Twenty inorganic COCs, 18 organic COCs, and two radionuclides were detected in sediment. These data are presented in Table 6.369.

Four Phase I surface-water samples were taken from NEDD (APPIX and RADs analyses). Four inorganic COCs and eight organic COCs were detected in surface water. No Phase II samples were collected. Data are presented in Table 6.370.

Old Northwest Firing Range (OFR)

Four Phase I soil samples were taken from OFR (TCL/TAL and RADs analyses). Seventeen inorganic COCs (five with maximum detections above background), two organic COCs, and one radionuclide were detected in soil. No Phase II samples were collected. These data are presented in Table 6.371.

Railroad Spur Yard Storage Area (RSY)

Seven soil samples were taken from RSY (six Phase I and one Phase II). Phase I samples were analyzed for TCL/TAL; Phase II samples were analyzed for RADs. Twenty inorganic COCs (10 with maximum detections above background), seven organic COCs, and two radionuclides were detected in soil. These data are presented in Table 6.372.

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Transformer Cleaning/Storage Pad (TCP)

Four Phase I soil samples were taken from TCP (TCL/TAL analyses). Twenty-one inorganic COCs (five with maximum detections above background) and eight organic COCs were detected in soil. No Phase II samples were collected. These data are presented in Table 6.373.

6.6.4.4 COCs by SWMUs (Location of Maximum Values)

Tables 6.374 and 6.375 list the locations of the maximum levels of inorganic, radionuclide, and organic COCs, by SWMU. As shown in the table below, NEDD had the highest total number of maximum values (28) among the SWMUs, accounting for 19 percent of the total number of maxima (all media). Three SWMUs, X-334, X-735, and X-745F, had no maximum values in any of the sampled media.

For inorganic COCs and radionuclides, NEDD had the greatest number of maximum values in sediment (7; 26 percent of all inorganic sediment maxima), X-114A had the greatest number in surface water (5; 45 percent of all inorganic surface water maxima), and X-745B had the greatest number in soil (6; 24 percent of all inorganic soil maxima). For radionuclides, the maximum concentration of technetium was detected at X-342A for sediment and at X-734 for soil. The maximum concentration of uranium was detected at NEDD for sediment and at X-745B for soil. No radionuclides were detected in surface water.

For organic COCs, NEDD had the greatest number of maximum values in sediment (13; 52 percent of all organic sediment maxima) and surface water (seven; 39 percent of all organic surface water maxima). X-333 had the greatest number of maximum values in soil (18; 44 percent of all organic soil maxima).

SWMUs With the Highest Number of Maximum COCs							
	Inorganics and Radionuclides			Organics			
SWMU	Sediment	Water	Soil	Sediment	Water	Soil	TOTAL
NEDD	7	1	NS[a]	13	7	NS	28
X-333	NS	NS	2	NS	NS	18	20
X-734	2	4	3	1	2	5	17
NDD	6	1	0	2	6	0	15
X-230J6	5	0	NS	6	3	NS	14
X-747H	NS	NS	2	NS	NS	12	14
X-745B	NS	NS	6	NS	NS	1	7
X-114A	NS	5	2	NS	0	NS	7
X-342A	3	1	NS	0	0	NS	4
X-344C/D	1	0	0	3	0	0	4
RSY	NS	NS	3	NS	NS	1	4
X-611A	3	NS	0	NS	NS	NS	3
X-533A	NS	NS	1	NS	NS	2	3
X-630	NS	NS	2	NS	NS	1	3
TCP	NS	NS	2	NS	NS	0	2
CPCB	NS	NS	0	NS	NS	1	1
OFR	NS	NS	1	NS	NS	0	1
X-745E	NS	NS	1	NS	NS	NS	1
X-745F	NS	NS	1	NS	NS	0	1
X-752	NS	NS	1	NS	NS	0	1
X-334	NS	NS	0	NS	NS	0	0
X-735	NS	NS	0	NS	NS	NS	0
Total for all SWMUs	27	12	27	25	18	41	150

[a] NS = No samples taken for this SWMU for this medium.

6.6.4.5 Unique COCs by SWMU

Table 6.340 provides a list of the "unique COCs" by SWMU. Unique COCs are those detected in only a single SWMU for a given environmental medium. As summarized in the table below, X-333 had the highest total number of unique COCs (nine) among the SWMUs, which accounted for 21 percent of the total number of unique COCs (all media). Ten (CPCB, OFR, X-334, X-342A, X-611A, X-630, X-735, X-745E, X-745F, and X-752) of the 22 SWMUs had no unique COCs in any of the sampled media.

There were unique COCs in each constituent class and in each environmental medium. Four (NDD, X-230J6, X-344C/D, and X-734) of the seven SWMUs at which sediments were sampled had at least one unique COC in sediment. Of the seven SWMUs at which surface water was sampled, all but two (X-342A and X-344C/D) had one or more unique COCs in surface water. Only seven (X-333, X-533A, X-734, X-745B, X-747H, RSY and TCP) of the 19 SWMUs at which soil was sampled had unique COCs in soil.

For inorganic COCs, X-230J6 had the greatest number of unique COCs in sediment (three), X-114A had the greatest number in surface water (three), and X-734 and TCP had the greatest number in soil (one each). For organic COCs, NDD and X-344C/D had the greatest number of unique COCs in sediment (2; 33 percent of all unique organic sediment COCs) and NDD had the greatest number of unique COCs in surface water (5; 50 percent of all unique organic surface water COCs). X-333 had the greatest number of unique COCs in soil (9; 56 percent of all unique organic soil COCs).

SWMUs with the Highest Number of Unique COCs							
	Inorganics			Organics			
SWMU	Sediment	Water	Soil	Sediment	Water	Soil	TOTAL
X-333	NS[a]	NS	0	NS	NS	9	9
NDD	1	0	NS	2	5	0	8
X-734	0	1	1	1	2	2	7
X-230J6	3	0	NS	1	2	NS	6
X-114A	NS	3	0	NS	0	NS	3
X-344C/D	0	0	0	2	0	0	2
X-747H	NS	NS	0	NS	NS	2	2
NEDD	0	0	NS	0	1	NS	1
RSY	NS	NS	0	NS	NS	1	1
TCP	NS	NS	1	NS	NS	0	1
X-533A	NS	NS	0	NS	NS	1	1
X-745B	NS	NS	0	NS	NS	1	1
CPCB	NS	NS	0	NS	NS	0	0
OFR	NS	NS	0	NS	NS	0	0
X-334	NS	NS	0	NS	NS	0	0
X-342	0	0	NS	0	0	NS	0
X-611A	0	NS	0	NS	NS	NS	0
X-630	NS	NS	0	NS	NS	0	0
X-735	NS	NS	0	NS	NS	NS	0
X-745E	NS	NS	0	NS	NS	NS	0
X-745F	NS	NS	NS	NS	NS	0	0
X-752	NS	NS	0	NS	NS	0	0
Total for All SWMUs	4	4	2	6	10	16	42

[a] NS = No samples taken for this SWMU for this medium.

6.6.5 Environmental Fate of COCs

The partitioning of chemicals into particular environmental compartments and their ultimate fate can be predicted from key physico-chemical factors. The available physico-chemical factors for the COCs under evaluation in the Quadrant IV PERA are presented in Appendix H.10. The information was obtained from a variety of secondary sources. The principal reference materials used were: (1) the Hazardous Substances Databank, a National Library of Medicine sponsored databank that contains information on the fate and toxicology of over 4,300 potentially hazardous chemicals; (2) the four-volume Handbook of Environmental Fate and Exposure Data by P.H. Howard (1989, 1990, 1991, and 1993); (3) Montgomery and Welkom (1990); and (4) CHEMFATE, a Syracuse Research Corporation Database. The factors that are most relevant for this assessment include: volatility, water solubility, sorption to solids, octanol water partitioning, and degradability.

Volatility describes how readily a compound will evaporate into the air from water, soil or sediment. Volatilization from water is expressed by the Henry's Law Constant, an air/water partition coefficient calculated by dividing the vapor pressure in atmospheres by water solubility in mole/m^3. Compounds with constants greater than 10^{-3} can be expected to volatilize readily from water, while those between 10^{-3} and 10^{-5} volatilize less readily. Compounds with constants less than 10^{-5} volatilize slowly. Volatility from soil or sediment tends to be expressed qualitatively (e.g., moderate, readily, or rapid).

Water solubility (mg/L) of a compound influences its partitioning to aqueous media. Highly water soluble chemicals have a tendency to remain dissolved in the water column and not partition to soil or sediment. Compounds with high water solubilities generally exhibit lower tendencies to bioconcentrate in aquatic organisms, a lower degree of volatility, and a greater likelihood of biodegradation.

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Adsorption is a measure of a compound's affinity for solids in soil or sediment. Adsorption is expressed in terms of partitioning, either K_d (adsorption coefficient; unitless expression of the equilibrium concentration in the solid phase versus in the water phase) or as K_{oc} (K_d normalized to the organic carbon content of the solid phase; again unitless). The higher the K_{oc} or K_d values, the higher the tendency to adhere very strongly to soil or sediment particles. K_{oc} values were used in calculating some of the sediment benchmarks for the PERA.

The octanol/water partition coefficient or K_{ow} is a measure of the relative partitioning between octanol and water and demonstrates whether a compound is hydrophilic or hydrophobic. It has also been shown to correlate well with bioconcentration factors in aquatic organisms and adsorption to soil or sediment particles and the potential to bioaccumulate in the food chain. Typically expressed as log K_{ow}, a value of three or less generally indicates that the chemical may not bioconcentrate to a significant degree (Maki and Duthie, 1978). A log K_{ow} of three equates to an aquatic species bioconcentration factor of about 100, using the correlation log BCF = 0.76 log K_{ow} - 0.23, from Lyman et al. (1990). Table 6.376 presents all compounds detected in any media with a log K_{ow} greater than 3. These compounds could then be used in food chain modelling to determine risks to organisms.

Degradability is an important factor in determining whether there will be significant loss of mass of a substance over time in the environment. The half-life ($T_{1/2}$), of a compound can be used to describe losses from either degradation (i.e., biological or abiotic) or from transfer from one compartment to another (e.g., volatilization from soil to air). The half-life is the time required for one-half of the mass of a compound to undergo the loss or degradation process.

6.6.6 Derivation of Screening Benchmarks

In the PERA, the estimated RME exposure concentration for a given COC in a given medium (i.e., represented by the 95 percent UCL on the mean or maximum measured level, whichever is less, for the quadrant-wide analysis, and the maximum measured level for the analysis of individual SWMUs) is compared to one or more adverse effect threshold values or benchmarks. The objective of this comparison is to screen the COCs to determine, qualitatively, which are likely (and, conversely, which are unlikely) to pose a risk to ecological receptors at the site. Where available, the effect threshold value is a medium-specific screening benchmark set forth by federal or state agencies. There are no established screening benchmarks, however, for a number of the PORTS COCs in one or more of the environmental media assessed. In these cases, the PERA calls for deriving screening benchmarks based on available data and best professional judgement. The general methods of deriving screening benchmarks proposed in the Quadrant IV Work Plan (Geraghty & Miller, Inc., 1992a) were used in this PERA. Some modifications were made to the PERA methodology based on instructions from ORNL personnel during the PERA process.

6.6.6.1 Surface-water Screening Benchmarks

The following procedure was used in the PERA. The calculated RME surface-water concentrations were compared to <u>all</u> benchmark values available for each COC. If the RME surface-water concentration exceeded <u>any</u> of these benchmarks, that COC was flagged for further analysis in a more detailed assessment, such as a BERA. If none of the benchmarks were exceeded, the COC was eliminated from further consideration.

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Surface-Water Screening Benchmarks from Suter et al. (1992)

Table 1 from Suter et al. (1992) contains up to eight benchmark values in surface waters for various inorganic and organic chemicals. This table has been reproduced as Table 6.377 for the applicable Quadrant IV COCs. According to the author, each benchmark was derived to protect aquatic organisms. The eight benchmarks include: (1) acute national ambient water quality benchmarks (NAWQC) or advisory values; (2) chronic NAWQC or advisory values;[9] (3) lowest chronic toxicity value reported for fish; (4) lowest chronic toxicity value reported for daphnids; (5) lowest test EC_{20} value (effect concentration correlated with a 20 percent response) reported for fish; (6) lowest test EC_{20} value reported for daphnids; (7) most sensitive aquatic species EC_{20}; and (8) largemouth bass population EC_{20}. The following screening procedure was used in the PERA. The calculated RME surface-water concentrations were compared to all benchmark values available for each COC as presented in Table 6.377. If the RME surface-water concentration exceeded any one benchmark, that COC was considered to be a potential hazard. If none of the benchmarks were exceeded, the COC was not considered a potential hazard. Where information was available for different valence states of a COC (i.e., arsenic III versus arsenic V), the more toxic of the two was used during the screening process.

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[9]Chronic advisory values included in the Suter et al. (1992) summary of benchmark values were not included as benchmarks in the PERA per instructions from ORNL (R. Hull, personal communication, 1994a), and do not appear in Table 6.377. Advisory values were substantially lower than other water quality guidelines and standards presented in Suter et al. (1992) and were judged to be too conservative to serve as a useful screening tool. The original screening methodology of Suter et al. (1992), which included comparison to chronic advisory values, required that the constituent concentration in surface water exceed two benchmarks in order for the chemical to be considered a potential hazard. Refinement of the methodology by eliminating advisory values and requiring an exceedence of only one benchmark value did not materially influence the outcome of the PERA surface water analysis.

All inorganic COCs detected in Quadrant IV surface water had one or more benchmarks available in Suter et al. (1992). Benchmarks were also available for 10 of the 17 organic COCs detected in surface water (alpha-BHC, gamma-BHC, chloroform, dibenzofuran, cis-1,2-dichloroethene, 2-hexanone, naphthalene, phenanthrene, 1,1,1-trichloroethane, and trichloroethene).

Surface-Water Screening Benchmarks Derived Using the PERA Methodology Described in the Quadrant IV Work Plan

When benchmarks were not available in Suter et al. (1992), they were derived using the PERA methodology described in the Quadrant IV Work Plan. An upper and lower benchmark was derived for the seven other organic COCs detected in surface water (bromodichloromethane, chloromethane, 2,4-D, dibromochloromethane, 1,4-dioxane, fluorene, and 2-methylnaphthalene). Because there were no NAWQCs available for these compounds, the lowest LC_{50} reported in the scientific literature was used as an upper benchmark. This value was divided by 100 to arrive at a lower benchmark (see Table 6.378). Thus, the surface-water concentrations (i.e., quadrant-wide RME and SWMU-specific maxima) for these seven organic COCs were compared to the upper and lower derived benchmarks in the PERA. Any COC that exceeded an upper or lower benchmark was flagged for further analysis in a more detailed assessment, such as a BERA.

6.6.6.2 Sediment Screening Benchmarks

Sediment screening benchmarks are presented in Tables 6.379 through 6.382. Screening benchmarks from Hull and Suter (1994) were used where available. Sediment benchmarks were available for inorganic COCs and ionic organic COCs (Hull and Suter, 1994). Sediment benchmarks for nonionic organic COCs were derived from aquatic benchmarks using the equilibrium partitioning approach.

Sediment Screening Benchmarks for Inorganic COCs

For each inorganic COC, there were upper and lower benchmark values available (Hull and Suter, 1994). If available, the National Oceanic and Atmospheric Administration (NOAA) Apparent Effects Threshold (AET) and NOAA Effects Range-Low (ER-L) were used as the upper and lower benchmarks, respectively (Long and Morgan, 1990). Where the AET was unavailable for a particular COC, the Effects Range-Median (ER-M) was used as the upper benchmark, if available. In cases where AET and ER-L or ER-M values were unavailable, instructions on inorganic sediment benchmarks were provided on a case by case basis by ORNL (Hull, personal communication, 1994b). The sources of all inorganic benchmark values are included in Table 6.379. If either the upper or lower benchmark was exceeded by the RME sediment concentration, the inorganic COC was retained for analysis in a more detailed assessment, such as a BERA.

Non-Ionic Organic Sediment Screening Benchmarks Calculated Using U.S. EPA Values

Sediment screening benchmarks (Table 6.380a) were available from U.S. EPA for four non-ionic COCs (acenaphthene, dieldrin, fluoranthene, and phenanthrene) (U.S. EPA, 1993a-e, as cited in Hull and Suter, 1994). These values were available in units of μg/g organic carbon and were converted to μg/kg sediment assuming 4 percent organic carbon in sediment in the absence of measured values (Mackay et al.,1992). This assumption of organic carbon value for sediment is a source of uncertainty in the PERA.

Non-Ionic Organic Sediment Screening Benchmarks Derived Using Aquatic Benchmarks from Suter et al. (1992)

For non-ionic (neutral) organics, Hull and Suter (1994) suggest that sediment benchmarks be derived by applying the equilibrium partitioning method (as described in

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U.S. EPA, 1993c) and surface-water screening benchmarks. These screening benchmarks were compared to RME concentrations using the same procedure as described for surface water. An exceedence of any of these benchmarks suggests a potential risk, and the COC was flagged for further evaluation in a more detailed assessment, such as a BERA. Sediment benchmarks for non-ionic organic COCs were derived by multiplying the surface-water screening benchmark by the K_{oc} and the F_{oc} (fraction organic carbon content of the sediment). The fraction organic carbon content of the sediment (F_{oc}) in Quadrant IV was assumed to be 4 percent in the absence of measured values (Mackay et al., 1992). The non-ionic organic sediment screening benchmarks are presented in Table 6.380b.

Non-Ionic Organic Sediment Screening Benchmarks Derived Using Surface-Water Benchmarks

There were eight non-ionic organic COCs for which aquatic benchmarks were not available in Suter et al. (1992). In the absence of aquatic screening benchmarks, the methodology described in the Quadrant IV Work Plan was used to derive both upper and lower aquatic screening benchmarks. The aquatic benchmarks were converted to sediment benchmarks using the equilibrium partitioning approach, as described above. These organic sediment benchmarks are presented in Table 6.381.

The upper aquatic benchmark was equivalent to the acute NAWQC. Where a NAWQC was unavailable, a NAWQC Lowest Observable Effect Level (LOEL) was used in its place. If an acute NAWQC LOEL value was unavailable, then the lowest chronic toxicity value was used. Where chronic data were unavailable, the lowest acute LC_{50} (concentration found to be lethal to 50 percent of a population of test organisms) available in the literature was used as the upper screening benchmark. Where an LC_{50} was unavailable, an EC_{50} was used. An EC_{50} is the concentration at which a particular effect is seen in 50 percent of a population of test organisms.

The lower aquatic benchmark was a chronic NAWQC, where available. When a chronic NAWQC was not available, the lowest chronic toxicity value was divided by a factor of 10 to estimate a lower screening benchmark. Where no chronic toxicity data were available, the lower screening benchmark was derived by dividing the lowest acute LC_{50} available in the literature by a factor of 100. These are conservative factors in that most measured chronic values would be higher than those estimated from these factors (Suter et al., 1983, as cited in the Quadrant IV Work Plan).

If either the upper or lower benchmark was exceeded by the RME concentration, the COC was flagged for further analysis in the BERA.

Ionic Organic Sediment Screening Benchmarks

For ionic organic COCs, Hull and Suter (1994) suggest the use of Washington State sediment quality standards (provided in Table 6 of Hull and Suter, 1994). That table is reproduced here as Table 6.382 for those ionic organics detected in sediment in Quadrant IV (2-methylphenol and phenol).

6.6.6.3 Plant Toxicity Screening Benchmarks

For terrestrial plants, the benchmark levels are selected such that a level of a COC below the benchmark allows for "vegetative cover that is sufficiently complete and robust to prevent erosion" (Quadrant IV Work Plan; Geraghty & Miller, Inc., 1992a). Under current use, this endpoint is not relevant for the western portion (inside Perimeter Road) of Quadrant IV because of the industrial nature (lack of vegetation due to pavement) of this area. However, Figure 6.2 shows that a substantial portion of Quadrant IV is comprised of forested and grassy areas and therefore appears to have ample vegetation or opportunity for vegetation to exist. This suggests that contaminant levels in much of the quadrant are

low enough that vegetation is able to exist. The extent to which plant species present may be pollution tolerant, however, is not known.

No relevant federal or state benchmarks were found relating soil chemical concentrations to plant toxicity. Therefore, benchmarks were derived based on the lowest concentration reported to be toxic to plants. The plant benchmarks for inorganic COCs were taken from Table 1 of Suter et al. (1993) and are reproduced here as Table 6.383. Phytotoxicity information was unavailable for six inorganic COCs (calcium, cyanide, lithium, magnesium, potassium, and sodium). Phytotoxicity information for organic COCs was obtained from the U.S. EPA's PHYTOTOX database (1993) and is presented in Table 6.384. There were 27 organic COCs for which no plant toxicity data were available, and therefore benchmarks could not be derived. COCs with no toxicity data could not be evaluated.

Some of the toxicity data was based on nutrient solution rather than soil exposure experiments. These results are flagged in Tables 6.383 and 6.384. Since concentration in nutrient solution was assumed to be equivalent to a concentration in soil, they would represent a conservative estimate of bioavailability and toxicity in the soil. This is a source of uncertainty in the PERA. In addition, a number of the phytotoxicity data were reported in concentrations expressed as molarity. These values were converted to μg/L as per the following example:

> A plant toxicity study using benzo(a)anthracene was identified in PHYTOTOX (Kochhar and Sabharwal, 1977). The experiment was conducted with *Nicotiana tabacum* in a nutrient medium. Morphogenetic effects were studied in plants at molar concentrations ranging from 10^{-11} to 10^{-5}. The lowest concentration of benzo(a)anthracene where effects were observed was 10^{-9} M. The equivalent concentration in soil was calculated by converting from grams/mol into μg/L (ppb):
>
> $(1 \times 10^{-9}$ mols/liter)(228 g/mol)$(10^{6}$ μg/g) = 0.227 μg/liter = 0.227 ppb

Soil benchmarks for inorganic COCs, in many cases, were well below the tentative background levels derived for the PORTS facility (see table below). This adds a considerable degree of uncertainty to the assessment of potential risks to plants for these COCs.

Inorganics With Plant Benchmarks Below Tentative Background Levels at PORTS		
COC	**Benchmark (mg/kg)**	**Background (mg/kg)**
Aluminum	50	29,268
Arsenic	10	23
Chromium	2	26
Iron	10	47,768
Nickel	1	51
Vanadium	2.5	63
Zinc	25	90

6.6.6.4 Soil Invertebrate Screening Benchmarks

Screening benchmarks for soil invertebrates are presented in Table 6.385. Benchmarks for some COCs were provided by ORNL (Will, personal communications, 1994a,b). For other COCs, benchmarks were derived if appropriate toxicity studies were available in the scientific literature. As per instructions from ORNL (Will, personal communication, 1994b), screening benchmarks for soil invertebrates were derived using the methodology for inorganic plant screening benchmarks outlined in Suter et al. (1993). This method is based on the NOAA method for deriving the ER-L for sediment screening benchmarks (Long and Morgan, 1990). The soil invertebrate screening benchmarks were derived by rank ordering all available lowest observed effect concentration (LOEC) values and then selecting the number that approximated the 10th percentile of the data. In every

case, less than ten studies were available for each COC, and the lowest toxicity value was chosen. In cases where LOEC data were not available, LC_{50} values divided by a factor of ten were substituted (Will, personal communication, 1994b).

6.6.6.5 Radionuclide Screening Benchmarks

Environmental media screening benchmarks for radionuclides are unavailable. Ecological risks from radionuclides were assessed on a quadrant-wide basis in the Phase I RFI, Quadrant I Ecological Risk Assessment (Geraghty & Miller, 1992b; Appendices L.4, L.5, and L.9). As an alternative to reproducing the detailed assessment done previously, the RME levels of radionuclides calculated for the Quadrant IV PERA have been compared with the RME levels calculated in the Quadrants I and II Phase I RFIs in order to screen for potential adverse impacts (see table below).

For the Phase I RFI, the radionuclide environmental monitoring data were converted to radiologic dose levels (μGy/hr) received by selected indicator species -- aquatic organisms (i.e., minnows, largemouth bass and suckers), semi-aquatic organisms (i.e., mink), and terrestrial organisms (i.e., great blue heron and white-tailed deer) -- using the CRITR method (NCRP, 1991). Technetium and uranium data were combined to obtain a measure of total radionuclide exposure. Exposures were estimated by combining data from the various environmental media sampled. In addition, the monitoring data from Quadrants I and II (uranium and technetium levels in soil, sediment, or surface water; from either Quadrant I or II) were combined into a single data set to determine radiologic dose levels that were then used in both the Quadrant I and Quadrant II Phase I RFI ecological risk assessments. These dose levels were compared to proposed "benchmarks" of 400 μGy/hr for aquatic organisms (NCRP, 1991) or a no adverse effect level on populations of 40 μGy/hr for terrestrial organsims (IAEA, 1991).

The table below presents the 1992 Quadrant I and II (Phase I) and 1994 Quadrant IV (Phase I and Phase II) RME concentrations, by environmental medium, for technetium and uranium. The potential for ecological damage from radionuclide exposure is evaluated in Section 6.6.7.1.3.

Comparison of 1992 Quadrant I/II and 1994 Quadrant IV RMEs for Radionculides

Environmental Medium	Technetium (pCi/kg)		Uranium (μg/g)	
	Quadrant I/II *(Phase I)*	Quadrant *IV (Phase I/II)*	Quadrant I/II *(Phase I)*	Quadrant *IV (Phase I/II)*
Sediment	4,100	889	7.0	8.4
Surface Water[2]	5.4	--	45	--
Soil	100,000	664	180	5.5

[1] Represents RME concentration in either Quadrant I or Quadrant II (Phase I) samples.
[2] In pCi/L for technetium and μg/L for uranium.

6.6.6.6 Screening Benchmarks for Bioaccumulation Potential

In addition to direct exposure to a COC in water, sediment, and/or soil, there is also potential exposure to an ecological receptor as a consequence of bioaccumulation through the food chain. Examples include:

- water/sediment ▸ fish ▸ piscivorous wildlife,
- soil ▸ plant ▸ herbivore, and
- soil ▸ soil invertebrate ▸ insectivore ▸ carnivore.

The bioaccumulation of lipophilic organic compounds can be screened using the octanol- water partitioning coefficient (K_{ow}) ; a log K_{ow} of three (3.0) or greater is considered a reasonable screen for bioaccumulation potential (Maki and Duthie, 1978).

Table 6.376 lists the organic COCs detected in Quadrant IV that have a log K_{ow} of greater than three. Where more than one K_{ow} was available, the midpoint of the range of values was used.

Screening benchmarks are not available for bioaccumulation of metals or for bio-uptake of any COC into higher plants. However, some heavy metals are known to be taken up by plants and organic forms of certain metals bioaccumulate in the food chain (e.g., organo-mercury and organo-lead). Although a screening benchmark, such as the K_{ow} used in lipophilic organics, is not available for plants, B_v values (Baes et al., 1984) could be used to calculate plant uptake and exposure in a more detailed assessment, such as a BERA.

In summary, with the exception of log K_{ow} values for organic compounds, screening level bioaccumulation benchmarks were not identified for the COCs in Quadrant IV. The compounds with a K_{ow} greater than three can be evaluated for food chain exposure to organisms in a more detailed assessment, such as a BERA.

The following SWMUs contain organic COCs with log K_{ow} values greater than three: X-230J6 (PAHs, Aroclor-1260, and 4-chlorophenyl-phenyl ether in sediment and PAHs in surface water); X-333 (PAHs, pesticides, Aroclor-1260, tetrachloroethene, 1,2,4-trichlorobenzene, and xylene in soil); X-334 (PAHs in soil); X-342 (PAHs in sediment); X-344C/D (PAHs, and dibenzofuran in sediment and PAHs in surface water); X-533 (PAHs and Aroclor-1260 in soil); X-630 (PAHs and Aroclor-1254 in soil); X-734 (PAHs, pesticides, and tetrachloroethene in sediment and PAHs, pesticides, Aroclor-1260, and tetrachloroethene in soil); X-745B (PAHs and PCBs in soil); X-745F (PAHs, Aroclor-1260, and dibenzofuran in soil); X-747H (PAHs and dibenzofuran in soil); X-752 (PAHs in soil); CPCB (PAHs, 4'4'-DDT, and tetrachloroethene in soil); NDD (PAHs, Aroclor-1260, dibenzofuran, and dieldrin in sediment and tetrachloroethene in soil); NEDD (PAHs

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and dibenzofuran in both sediment and surface water); OFR (PAHs in soil); RSU (PAHs in soil); and TCP (PAHs and Aroclor-1260 in soil).

6.6.7 Comparison of Constituents of Concern with Screening Benchmarks

The purpose of comparing RME concentrations of COCs to available or derived toxicity benchmarks is to screen the COCs for potential ecological risks and to identify those COCS which require a further analysis in a more detailed ecological risk assessment, such as a BERA. The PERA approach involved a determination of whether or not screening benchmarks were exceeded. In cases where the PERA analysis results in an exceedence, regardless of the magnitude, the COC (and associated environmental medium and SWMU) was flagged for further consideration. In cases where the screening benchmarks were not exceeded, the COC (and environmental medium and SWMU) was eliminated from further consideration. The elimination of COCs by this method can be made with confidence because of the generally conservative assumptions used in deriving the screening benchmarks. In the Quadrant IV PERA, there are some COCs for which screening benchmarks could not be developed for a particular medium due to lack of appropriate toxicity data; these COCs are noted in Table 6.386.

6.6.7.1 Quadrant-Wide Comparisons

Tables 6.387 to 6.389 summarize the quadrant-wide COC data by environmental medium. Table 6.390 summarizes the results of comparing the quadrant-wide RME concentration for each COC, by environmental medium, to the benchmarks derived using the methods described in previous sections.

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6.6.7.1.1 Inorganic COCs

Twenty-five inorganic COCs were detected in sediments, 11 in surface water, and 23 in soil. Most inorganic COCs detected in soil, however, had RME levels below background (16 out of 25); accordingly, these 16 COCs were not considered further in the quadrant-wide comparison. Benchmarks were available, or derived, for many of the inorganic COCs that were taken through the quadrant-wide comparison: sediment (14/25), surface water (11/11), plant toxicity in soil (2/7), and invertebrate toxicity in soil (0/7).

There were 12 exceedences in sediment (antimony, arsenic, barium, chromium, copper, cyanide, iron, lead, manganese, nickel, silver, and zinc); six in surface water (cadmium, chromium, cobalt, lead, nickel, and zinc); and one exceedence in soil (lithium exceeded the plant toxicity benchmark). As a result of the quadrant-wide comparison, one inorganic COC (mercury) was dropped from further analysis in the PERA. Mercury was dropped from further analysis because it had benchmarks available in every environmental medium in which it was detected and did not exceed any of these benchmarks. All other detected inorganic COCs either exceeded at least one benchmark in a medium, or did not have a benchmark in a medium, and were considered for further analysis in a more detailed assessment such as a BERA.

6.6.7.1.2 Organic COCs

Twenty-five of the 51 organic COCs were detected in sediments, 18 in surface water, and 41 in soil. Benchmarks were available, or derived, for the organic COCs as follows: sediment (21/25), surface water (18/18), plant toxicity in soil (14/41), and invertebrate toxicity in soil (4/41).

There were 13 exceedences in sediment (acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, 2-methylphenol, phenanthrene, phenol, and pyrene); none in surface water; four in soil for exceedences of plant toxicity benchmarks (benzo(a)anthracene, benzo(a)pyrene, 4,4'-DDT, and dibenz(a,h)anthracene); and two in soil for exceedences of invertebrate toxicity benchmarks (phenol and 1,2,4-trichlorobenzene). Based on the quadrant-wide analysis, nine organic COCs were dropped from further consideration (alpha-BHC, bromodichloromethane, chloromethane, 2,4-D, dibromochloromethane, cis-1,2-dichloroethene, dieldrin, 1,4-dioxane, and 2-hexanone).

6.6.7.1.3 Radionuclides

As stated in Section 6.6.6.5, a screening-level analysis of potential ecological risks associated with radionuclides has been performed. This analysis consisted of comparing the quadrant-wide RME concentrations of uranium and technetium in Quadrant IV media to the RME concentrations in the Quadrant I/Quadrant II Phase I RFI. A detailed assessment of potential ecological risk for radionuclides was performed as part of the Phase I RFIs for Quadrants I and II.

The analysis of potential ecological risk from exposure to radionuclides presented in the 1992 Quadrant I/Quadrant II Phase I RFIs showed negligible risks to fish and wildlife with the exception of the great blue heron, for which the calculated dose in μGy/hr exceeded the screening benchmark by a marginal factor of 1.1. In interpreting the results of the analysis for the heron, consideration was given to the conservative assumptions incorporated in estimating radionuclide dose to the heron, including the following: the use of the detection limit for radionuclides in fish tissue (a major component of the heron diet) where tissue levels were reported as non-detects; the assumption of no excretion of radionuclides from the heron; and the assumption of year-round residency for the great blue

heron, a migratory species. Given the nature of these assumptions and the small factor by which the benchmark for the heron was exceeded, it is unlikely that radionuclide levels in Quadrant I/Quadrant II media present a significant risk to ecological receptors.

The table in Section 6.6.6.5 compares average Quadrant IV radionuclide concentrations (based on Phase I and II sampling data collected through 1994) to average Quadrant I and II radionuclide concentrations (based on 1992 Phase I sampling data). Radionuclides were not detected in the 1994 Quadrant IV surface water samples and therefore can be eliminated from further consideration for potential ecological risk in Quadrant IV. Radionuclide levels in 1994 Quadrant IV soil samples were substantially lower than in 1992 Quadrant I/II soil samples and should therefore pose negligible risks. Technetium levels were substantially lower in Quadrant IV sediment samples than in Quadrant I/II sediment samples (889 versus 4,100 pCi/kg) while uranium levels were slightly higher (8.4 versus 7.0 μg/g). In summary, the RME concentrations for radionuclides in Quadrant IV were lower than the RME concentrations calculated in the Quadrant I/II Phase I assessment with the exception of the Quadrant IV RME concentration of uranium in sediment, which slightly exceeded the Quadrant I/II RME concentration. Because the Quadrant I/II Phase I assessment suggested that radionuclides should not present a significant risk to ecological receptors, radionuclide levels in Quadrant IV media should generally not present a significant ecological risk. The current analysis does not allow more definitive conclusions to be reached about uranium levels in sediment; however, additional consideration of the potential ecological risks posed by radionuclides appears in the BERA for the Upper Little Beaver Creek and Big Run Creek watersheds (ORNL, 1994b).

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6.6.7.2 SWMU by SWMU Comparison

The following subsections summarize, first by environmental medium and then by SWMU, the number of chemicals detected and the number of chemicals in which RME levels exceeded benchmarks. The relevant data are summarized in Appendices H.11 and H.12, for inorganic and organic COCs, respectively.

6.6.7.2.1 Analysis by Environmental Medium

Sediment

Inorganic chemicals were analyzed for in sediment at seven SWMUs (X-230J6, X-342A, X-344C/D, X-611A, X-734, NDD, and NEDD); organic chemicals were also analyzed for in sediment at all but X-611A. SWMU X-230J6 had the greatest number of inorganic COCs detected in sediment (26) and the most inorganic COCs for which there were benchmarks (13). X-230J6 also had the greatest number of inorganic COCs exceeding benchmarks (13), and, along with NEDD, had the higher percentage of inorganic COCs above a benchmark (100 percent). All SWMUs had at least one exceedence of sediment inorganic benchmarks. Two inorganics (barium and iron) exceeded benchmarks at all seven SWMUs; zinc exceeded at six of seven SWMUs.

Inorganics[a] - Sediment			
SWMU	**Number of COCs Detected**	**Number with Benchmarks**	**Number Exceeding Benchmarks (% Evaluated)**
X-230J6	26	13	13 (100%)
NEDD	22	12	12 (100%)
NDD	23	12	10 (83%)
X-344C/D	19	10	7 (70%)

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Inorganics[a] - Sediment			
SWMU	Number of COCs Detected	Number with Benchmarks	Number Exceeding Benchmarks (% Evaluated)
X-342A	20	10	5 (50%)
X-734	20	10	5 (50%)
X-611A	15	8	3 (38%)
[a] Includes radionuclides.			

Three SWMUs (NDD, X-230J6, and X-344C/D) had the most organic COCs detected (20) in sediment; NDD had the most organic COCs with benchmarks (18). NEDD and X-230J6 had the greatest number of organic COCs that exceeded benchmarks (14), while NEDD had the highest percentage of organic COCs exceeding sediment benchmarks (93 percent). All six SWMUs at which organic chemicals were analyzed for in sediments had at least one exceedence of sediment benchmarks. Four organic COCs (anthracene, benzo[g,h,i]perylene, chrysene, and pyrene) exceeded sediment benchmarks at all six SWMUs.

Organics - Sediment			
SWMU	Number of COCs Detected	Number with Benchmarks	Number Exceeding Benchmarks (% Evaluated)
NEDD	18	15	14 (93%)
X-230J6	20	16	14 (88%)
NDD	20	18	11 (61%)
X-344C/D	20	17	8 (47%)
X-734	19	16	8 (50%)
X-342	14	12	4 (33%)
X-611A	Not Sampled	--	-----

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Surface Water

Surface-water samples were taken at seven SWMUs (X-114A, X-230J6, X-342, X-344C/D, X-734, NDD, and NEDD). SWMUs X-734 and X-114A had the most inorganic COCs detected (8) in surface water and the most detected for which benchmarks were available (8); all detected inorganic COCs had available benchmarks. For inorganics in surface water, SWMUs X-734 and X-114A also had the greatest number (6) of inorganic COCs exceeding benchmarks; X-342 had the highest percentage (100 percent) of inorganic COCs exceeding benchmarks. No inorganic COC exceeded surface-water benchmarks at all seven SWMUs; zinc exceeded benchmarks most frequently (six of seven SWMUs).

Inorganics[a] - Surface Water			
SWMU	Number of COCs Detected	Number with Benchmarks	Number Exceeding Benchmarks (% Evaluated)
X-342	1	1	1 (100%)
X-734	8	8	6 (75%)
X-114A	8	8	6 (75%)
X-344C/D	3	3	2 (67%)
NDD	4	4	2 (50%)
NEDD	4	4	2 (50%)
X-230J6	4	4	2 (50%)
[a] Includes radionuclides.			

SWMU X-230J6 had the most organic COCs detected in surface water (9) and the most organic COCs with benchmarks (9); all detected organic COCs had available benchmarks. No organic COCs were detected in surface water at three SWMUs (X-114A, X-342, and X-344C/D). For organic COCs, there were no exceedences of surface-water benchmarks at any SWMU.

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Organics - Surface Water			
SWMU	Number of COCs Detected	Number with Benchmarks	Number Exceeding Benchmarks (% Evaluated)
X-230J6	9	9	0 (0%)
NDD	8	8	0 (0%)
NEDD	8	8	0 (0%)
X-734	2	2	0 (0%)
X-342A	0	--	----
X-344C/D	0	--	----
X-114A	0	--	----

Soil

Soil samples were analyzed for inorganic chemical constituents at 18 SWMUs (CPCB, OFR, RSY, TCP, X-114A, X-333, X-334, X-344C/D, X-533A, X-611A, X-630, X-734, X-735, X-745B, X-745E, X-745F, X-747H, and X-752); radionuclides were the only "inorganics" sampled at NDD. Soil samples were analyzed for organic chemical constituents at 15 SWMUs (CPCB, NDD, OFR, RSY, TCP, X-333, X-334, X-344C/D, X-533A, X-630, X-734, X-745B, X-745F, X-747H, and X-752). Maximum concentrations of inorganic chemicals in soils were compared to background soil concentrations, where available (Table 6.339). A number of inorganic COCs were dropped from consideration at several SWMUs because the maximum levels were below background (Table 6.339). Inorganic COCs detected at levels above background and all detected organic COCs were compared to available soil benchmarks, which were based on phytotoxicity and toxicity to soil invertebrates.

Toxicity to Plants: SWMU X-734 had the greatest number of inorganic COCs detected in soil at levels above background (12). X-333 had the greatest number of

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phytotoxicity benchmarks available (8) and the greatest number of exceedences (5). CPCB and OFR had the greatest percentage of exceedences of inorganic phytotoxicity benchmarks (100 percent). No inorganic COC exceeded its plant toxicity benchmark at every SWMU; zinc exceeded its soil phytotoxicity benchmark most frequently (10 of 18 SWMUs). No inorganic chemicals were detected at levels above background at two SWMUs (X-611A and X-735).

Inorganics[a] - Phytotoxicity in Soil			
SWMU	Number of COCs Detected Above Background	Number with Benchmarks	Number Exceeding Benchmarks (% Evaluated)
X-333	11	8	5 (63%)
X-630	9	6	4 (67%)
X-114A	7	4	3 (75%)
X-745B	10	5	3 (60%)
X-734	12	6	3 (50%)
RSY	11	7	3 (43%)
CPCB	5	2	2 (100%)
OFR	5	2	2 (100%)
X-747H	10	4	2 (50%)
X-533A	7	4	2 (50%)
X-745F	7	3	2 (29%)
TCP	6	2	1 (50%)
X-334	5	2	1 (50%)
X-752	6	3	1 (33%)
X-344C/D	5	1	0 (0%)
X-745E	4	1	0 (0%)
NDD[b]	1	0	-----
X-611A	0	--	-----
X-735	0	--	-----

[a] Includes radionuclides.
[b] Sampled for radionuclides only.

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SWMU X-333 had the greatest number of organic COCs detected (32), the greatest number of organic COCs with phytotoxicity benchmarks (8), and, along with X-734 and X-747H, the greatest number of organic COCs exceeding plant toxicity benchmarks (5). X-334, X-752, and X-344C/D had the greatest percentage of organic COCs exceeding plant toxicity benchmarks (100 percent). No organic COCs exceeded plant toxicity benchmarks at every SWMU; benzo(a)pyrene and benzo(a)anthracene exceeded their respective soil phytotoxicity benchmarks most frequently (11 of 15 SWMUs).

Organics - Phytotoxicity in Soil			
SWMU	**Number of COCs Detected**	**Number with Benchmarks**	**Number Exceeding Benchmarks (% Evaluated)**
X-734	25	7	5 (71%)
X-747H	20	7	5 (71%)
X-333	32	8	5 (63%)
X-745B	21	7	4 (57%)
X-334	10	2	2 (100%)
X-752	7	2	2 (100%)
RSY	7	3	2 (67%)
CPCB	14	4	2 (50%)
X-630	16	5	2 (40%)
X-745F	16	5	2 (40%)
X-344C/D	3	1	1 (100%)
TCP	8	2	1 (50%)
X-533A	7	2	0 (0%)
NDD	1	0	-----
OFR	2	0	-----

Toxicity to Soil Invertebrates: SWMU X-734 had the greatest number of inorganic COCs detected in soil at levels above background (12), RSY had the greatest number of soil invertebrate toxicity benchmarks available (5), and X-630 had the greatest number of exceedences (2). X-334 had the greatest percentage of exceedences of inorganic soil invertebrate toxicity benchmarks (100 percent). No inorganic COC exceeded its soil invertebrate toxicity benchmark at every SWMU; chromium exceeded its soil invertebrate toxicity benchmark most frequently (3 of 18 SWMUs). No inorganic chemicals were detected at levels above background at two SWMUs (X-611A and X-735).

Inorganics[a] - Invertebrate Toxicity in Soil			
SWMU	Number of COCs Detected Above Background	Number with Benchmarks	Number Exceeding Benchmarks (% Evaluated)
X-630	9	4	2 (50%)
X-334	5	1	1 (100%)
X-333	11	3	1 (33%)
X-533A	7	3	1 (33%)
X-745B	10	4	1 (25%)
CPCB	5	1	0 (0%)
OFR	5	2	0 (0%)
RSY	11	5	0 (0%)
X-114A	7	3	0 (0%)
X-734	12	3	0 (0%)
X-747H	10	1	0 (0%)
X-752	6	1	0 (0%)
X-745F	7	2	0 (0%)
TCP	6	0	-----
X-344C/D	5	0	-----
X-745E	4	0	-----
NDD[b]	1	0	-----
X-611A	0	--	-----

Inorganics[a] - Invertebrate Toxicity in Soil			
SWMU	Number of COCs Detected Above Background	Number with Benchmarks	Number Exceeding Benchmarks (% Evaluated)
X-735	0	--	-----

[a] Includes radionuclides.
[b] Sampled for radionuclides only.

SWMU X-333 had the greatest number of organic COCs detected (32) and the greatest number of organic COCs with soil invertebrate toxicity benchmarks (3). X-747H had the greatest number (2) and percentage (100 percent) of organic COCs exceeding soil invertebrate toxicity benchmarks. No organic COC exceeded the soil invertebrate toxicity benchmark at every SWMU; phenol, 1,2,4-trichlorobenzene, and fluorene each exceeded its respective soil invertebrate toxicity benchmark once.

Organics - Invertebrate Toxicity in Soil			
SWMU	Number of COCs Detected	Number with Benchmarks	Number Exceeding Benchmarks (% Evaluated)
X-747H	20	2	2 (100%)
X-333	32	3	1 (33%)
X-630	16	1	0 (0%)
X-734	25	1	0 (0%)
X-745B	21	1	0 (0%)
X-745F	16	1	0 (0%)
CPCB	14	0	-----
NDD	1	0	-----
OFR	2	0	-----
RSY	7	0	-----
TCP	8	0	-----

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Organics - Invertebrate Toxicity in Soil			
SWMU	Number of COCs Detected	Number with Benchmarks	Number Exceeding Benchmarks (% Evaluated)
X-334	10	0	-----
X-344C/D	3	0	-----
X-533A	7	0	-----
X-752	7	0	-----

6.6.7.2.2 Analysis by SWMU

Following is a detailed SWMU by SWMU analysis in which SWMU-specific RME concentrations (as presented in Tables 6.341 to 6.373) were compared to the benchmarks presented in Tables 6.377 to 6.385. Unlike the quadrant-wide analysis, the RME concentrations for the SWMU by SWMU analysis were always the maximum detected concentration. Appendix H.11 (inorganic COCs) and Appendix H.12 (organic COCs) contain lists of detects and exceedences by SWMU.

X-114A Firing Range

Surface water and soil were sampled at SWMU X-114A. Nineteen inorganic COCs were detected in X-114A soils; organic COCs were not sampled for in soil. Twelve inorganic COCs had maximum values below background and were not considered further in the analysis. Of the seven inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for four and three (iron, lead, and zinc) were exceeded. Soil invertebrate benchmarks were available for three of the seven inorganic COCs and there were no exceedences. The quadrant-wide maximum soil levels

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for cadmium and vanadium occurred at X-114A. No detected chemicals in soil were unique to SWMU X-114A.

In surface water, nine inorganic COCs and no organic COCs were detected. Benchmarks were available for all eight inorganic COCs and there were six exceedences (beryllium, cadmium, cobalt, lead, nickel, and zinc). Quadrant-wide maximum surface-water concentrations occurred at X-114A for beryllium, cadmium, cobalt, lead, and nickel. Beryllium, cadmium, and nickel were unique to this SWMU in surface water.

X-230J6 Northeast Holding Pond, Monitoring Facility, and Secondary Oil Collection Basin

Surface-water and sediment samples were taken at X-230J6. In sediment, 20 organic COCs and 26 inorganic COCs were detected. Benchmarks were available for 13 inorganic COCs and 12 (antimony, arsenic, barium, chromium, copper, iron, lead, manganese, mercury, nickel, zinc, and total cyanide) were exceeded. For organic COCs, benchmarks were available for 16 COCs and 14 (dibenzofuran, 2-methylnaphthalene, acenaphthene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, fluoranthene, naphthalene, phenanthrene, and pyrene) were exceeded. The quadrant-wide sediment maximum values for five inorganics (antimony, cadmium, selenium, thallium, and vanadium) and six organics (Aroclor-1260, 2-methylnaphthalene, benzo[b]fluoranthene, dibenz[a,h]anthracene, naphthalene, and 4-chlorophenyl-phenyl ether) occurred at X-230J6. Antimony, selenium, thallium, and 4-chlorophenyl-phenyl ether were unique to this SWMU in sediment.

In surface water, four inorganic COCs and nine organic COCs were detected. For inorganic COCs, benchmarks were available for all four COCs and there were two exceedences (chromium and zinc). For organic COCs, benchmarks were available for all nine COCs and there were no exceedences. Quadrant-wide maximum surface-water

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concentrations occurred at X-230J6 for bromodichloromethane, chloroform, and dibromochloromethane. Bromodichloromethane and dibromochloromethane were unique to this SWMU in surface water.

X-333 Process Building

Only soil was sampled at SWMU X-333. Twenty-one inorganic and 32 organic COCs were detected in X-333 soils. Ten inorganic COCs had maximum values below background and were not considered further in the analysis. Of the 11 inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for eight and five (arsenic, iron, lithium, nickel, and zinc) were exceeded. Soil invertebrate benchmarks were available for three of the 11 inorganic COCs and there was one exceedence (arsenic). Of the 32 organic COCs detected, plant toxicity benchmarks were available for eight and five (acenaphthene, anthracene, benzo[a]anthracene, benzo[a]pyrene, and dibenz[a,h]anthracene) were exceeded. Soil invertebrate benchmarks were available for three organic COCs and there was one exceedence (1,2,4-trichlorobenzene).

The quadrant-wide maximum soil levels for two inorganic COCs (barium and nickel) and 18 organic COCs (Aroclor-1260, gamma-BHC, 1,2,4-trichlorobenzene, 2,4-dimethylphenol, 2-methylphenol, 3/4-methylphenol, benzene, chlorobenzene, ethylbenzene, xylene, anthracene, benzo[a]anthracene, benzo[b]fluoranthene, benzo[g,h,i]perylene, fluoranthene, indeno[1,2,3-cd]pyrene, phenanthrene, and pyrene) occurred at X-333. Gamma-BHC, 1,2,4-trichlorobenzene, 2,4-dimethylphenol, 2-methylphenol, 3/4-methylphenol, benzene, chlorobenzene, ethylbenzene, and xylene were the only detected chemicals in soil unique to SWMU X-333.

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X-334 Transformer Storage and Cleaning Building

Only soil was sampled at SWMU X-334. Twenty inorganic and ten organic COCs were detected in X-334 soils. Fifteen inorganic COCs had maximum values below background and were not considered further in the analysis. Of the five inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for two and one (chromium) was exceeded. Soil invertebrate benchmarks were available for one of the five inorganic COCs (chromium) and it was exceeded. Of the ten organic COCs detected, plant toxicity benchmarks were available for two (benzo(a)anthracene and benzo(a)pyrene) and both were exceeded. Soil invertebrate benchmarks were not available for any of the organic COCs at this SWMU. No quadrant-wide maximum soil concentrations occurred at SWMU X-334 and no chemical was unique to this SWMU in soil.

X-342 Feed Vaporization and Fluorine Generation Building; X-342B Fluorine Storage Building; X-342C Waste HF Neutralization Pit (X-342)

Surface-water and sediment samples were taken at X-342 and associated areas. In sediment, 14 organic COCs and 20 inorganic COCs were detected. Benchmarks were available for 10 inorganic COCs and five (barium, copper, iron, nickel, and zinc) were exceeded. For organic COCs, benchmarks were available for 12 COCs and four (anthracene, benzo[g,h,i]perylene, chrysene, and pyrene) were exceeded. The quadrant-wide sediment maximum values for two inorganic COCs (magnesium and nickel) and one radionuclide (technetium) occurred at X-342. No chemicals were unique to this SWMU in sediment.

In surface water, one inorganic COC and no organic COCs were detected. For the inorganic COC (fluoride), a benchmark was available and it was exceeded. Quadrant-wide

maximum surface-water concentrations occurred at X-342A for fluoride. No chemicals were unique to this SWMU in surface water.

X-344C/D HF Storage Facility and HF Neutralization Pit (X-344C/D)

Surface-water, sediment, and soil samples were taken at X-344C/D. In sediment, 20 organic COCs and 19 inorganic COCs were detected. Benchmarks were available for 10 inorganic COCs and seven (barium, chromium, copper, iron, mercury, nickel, and zinc) were exceeded. For organic COCs, benchmarks were available for 17 COCs and eight (2-methylphenol, phenol, anthracene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, and pyrene) were exceeded. The quadrant-wide maximum sediment concentrations for fluoride, 2-methylphenol, phenol, and acenaphthylene occurred at X-344C/D. Phenol and 2-methylphenol were unique to this SWMU in sediment.

In surface water, three inorganic and no organic COCs were detected. For inorganic COCs, benchmarks were available for all three COCs and two (fluoride and zinc) were exceeded. No quadrant-wide maximum surface-water concentrations occurred in SWMU X-344C/D and no chemical was unique to this SWMU in surface water.

In soil, 20 inorganic and three organic COCs were detected in X-344C/D soils. Fifteen inorganic COCs had maximum values below background levels and were not considered further in the analysis. Of the five inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for one (fluoride) and it was not exceeded. No soil invertebrate benchmarks were available for any of the five inorganic COCs. Of the three organic COCs detected, plant toxicity benchmarks were available for one (benzo(a)anthracene) and it was exceeded. Soil invertebrate benchmarks were not available for the three organic COCs. No quadrant-wide

maximum soil concentrations occurred at SWMU X-344C/D and no chemical was unique to this SWMU in soil.

X-533A Switchyard; X-533B Switch House; X-533C Test and Repair Building; X-533D Oil House and Associated French Drains; X-533E Valve House; X-533F Valve House; X-533H Gas Reclaiming Cart Garage (X-533A)

Only soil was sampled at SWMU X-533A and associated areas. Twenty inorganic and seven organic COCs were detected in X-533A soils. Thirteen inorganic COCs had maximum values below background and were not considered further in the analysis. Of the seven inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for four and two (arsenic and zinc) were exceeded. Soil invertebrate benchmarks were available for three of the seven inorganic COCs and there was one exceedence (arsenic). Of the seven organic COCs detected, plant toxicity benchmarks were available for two and neither was exceeded. Soil invertebrate benchmarks were not available for the organic COCs.

The quadrant-wide maximum soil levels for arsenic, 1,1,1-trichloroethane, and trichloroethene occurred at X-533A. Trichloroethene was unique to SWMU X-533A in soils.

X-611A North, Middle, and South Lime Sludge Lagoons

Sediment and soil were sampled at SWMU X-611A. In sediment, 15 inorganic COCs were detected; organic chemicals were not analyzed for. Benchmarks were available for eight of the inorganic COCs and three (barium, iron, and manganese) were exceeded. The quadrant-wide maximum sediment concentrations for beryllium, calcium, and sodium occurred at X-611A. No chemicals were unique to this SWMU in sediment.

In soil, two inorganic COCs were detected in X-611A soils; organic chemicals were not analyzed for in soil. Both inorganic COCs had maximum values below background and were not considered further in the analysis. No quadrant-wide maximum soil concentrations occurred at SWMU X-611A and no chemical was unique to this SWMU in soil.

X-630 Recirculating Water Pump House; X-630-2A Cooling Tower; X-630-2B Cooling Tower; X-630-3 Acid Handling Station (X-630)

Only soil was sampled at SWMU X-630 and associated areas. Twenty inorganic and 16 organic COCs were detected in X-630 soils. Eleven inorganic COCs had maximum values below background and were not considered further in the analysis. Of the nine inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for six and four (chromium, iron, mercury, and zinc) were exceeded. Soil invertebrate benchmarks were available for four of the nine inorganic COCs and two (chromium and mercury) were exceeded. Of the 16 organic COCs detected, plant toxicity benchmarks were available for five and two (benzo[a]pyrene and benzo(a)anthracene) were exceeded. Soil invertebrate benchmarks were available for one organic COC and it was not exceeded.

The quadrant-wide maximum soil levels for two inorganic COCs (mercury and vanadium) and one organic COC (Aroclor-1254) occurred at X-630. No detected chemicals in soils were unique to SWMU X-630.

X-734 Old Sanitary Landfill; X-734A Landfill Utility Building (X-734)

Surface-water, sediment, and soil samples were taken at X-734. In sediment, 19 organic COCs and 20 inorganic COCs were detected. Benchmarks were available for ten inorganic COCs and five (arsenic, barium, iron, manganese, and zinc) were exceeded. For

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organic COCs, benchmarks were available for 16 COCs and eight (anthracene, benzo[a]anthracene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, fluoranthene, phenanthrene, and pyrene) were exceeded. The quadrant-wide maximum sediment values for arsenic, iron, and tetrachloroethene occurred at X-734. Tetrachloroethene was unique to this SWMU in sediment.

In surface water, eight inorganic and two organic COCs were detected. For inorganic COCs, benchmarks were available for all eight COCs and six (arsenic, chromium, cobalt, lead, vanadium, and zinc) were exceeded. For organic COCs, benchmarks were available for both COCs and neither was exceeded. Quadrant-wide maximum surface-water concentrations occurred at SWMU X-734 for four inorganics (arsenic, barium, vanadium, and zinc) and two organics (gamma-BHC and alpha-BHC). Arsenic, gamma-BHC, and alpha-BHC were unique to this SWMU in surface water.

In soil, 23 inorganic and 25 organic COCs were detected in X-734 soils. Eleven inorganic COCs had maximum values below background levels and were not considered further in the analysis. Of the 12 inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for six and three (arsenic, lithium, and mercury) were exceeded. Soil invertebrate benchmarks were available for three of the 12 inorganic COCs and none were exceeded. Of the 25 organic COCs detected, plant toxicity benchmarks were available for seven and five (4,4'-DDT, acenaphthene, benzo[a]anthracene, benzo[a]pyrene, and dibenz[a,h]anthracene) were exceeded. Soil invertebrate benchmarks were available for only one organic COC and it was not exceeded.

Quadrant-wide maximum soil concentrations occurred at SWMU X-734 for two inorganics (lithium and thallium), one radionuclide (technetium), and five organics (4,4'-DDE, 4,4'-DDT, endrin ketone, methoxychlor, and styrene). Thallium, 4,4'-DDE, and endrin ketone were unique to this SWMU in soil.

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X-735 Sanitary Landfill; X-735A Landfill Utility Building (X-735)

Only soil was sampled at X-735. Sixteen inorganic COCs were detected in X-735 soils; organic chemicals were not analyzed for. All 16 inorganic COCs had maximum values below background and were not considered further in the analysis. No quadrant-wide maximum soil concentrations occurred in SWMU X-735 and no chemical was unique to this SWMU in soil.

X-745B Enrichment Process Gas Yard

Only soil was sampled at SWMU X-745B. Twenty inorganic and 21 organic COCs were detected in X-745B soils. Ten inorganic COCs had maximum values below background and were not considered further in the analysis. Of the ten inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for five and three (chromium, lead, and zinc) were exceeded. Soil invertebrate benchmarks were available for four of the ten inorganic COCs and one (chromium) was exceeded. Of the 21 organic COCs detected, plant toxicity benchmarks were available for seven and four (acenaphthene, benzo[a]anthracene, benzo[a]pyrene, and dibenz[a,h]anthracene) were exceeded. Soil invertebrate benchmarks were available for only one organic COC and it was not exceeded.

The quadrant-wide maximum soil levels for six inorganic (calcium, chromium, copper, fluoride, magnesium, and zinc), one radionuclide (total uranium), and one organic (4-nitroaniline) COCs occurred at X-745B. 4-Nitroaniline was unique to SWMU X-745B in soil.

X-745E Northwest International Process Gas Yard (X-745E) 2388

Only soil was sampled at SWMU X-745E. Twenty inorganic COCs were detected in X-745E soils; organic chemicals were not analyzed for. Sixteen inorganic COCs had maximum values below background and were not considered further in the analysis. Of the four inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for one and it was not exceeded. Soil invertebrate benchmarks were not available for any of the four inorganic COCs. The quadrant-wide maximum soil levels for magnesium occurred at X-745E. No chemicals in soils were unique to SWMU X-745E.

X-745F North Process Gas Stockpile Yard (X-745F)

Only soil was sampled at SWMU X-745F. Twenty inorganic COCs, sixteen organic COCs and one radionuclide were detected in X-745F soils. Fourteen inorganic COCs had maximum values below background and were not considered further in the analysis. Of the six inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for three and two (mercury and zinc) were exceeded. Soil invertebrate benchmarks were available for two inorganic COCs and neither was exceeded. Of the 15 organic COCs detected, plant toxicity benchmarks were available for five and two (benzo[a]anthracene and benzo[a]pyrene) were exceeded. Soil invertebrate benchmarks were available for only one organic COC and it was not exceeded. One radionuclide was present at levels above background, but plant toxicity and soil invertebrate benchmarks were not available. No quadrant-wide maximum soil concentrations occurred at SWMU X-745F and no chemical was unique to this SWMU in soil.

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X-747H Northwest Surplus and Scrap Yard (X-747H)

Only soil was sampled at SWMU X-747H. Twenty-one inorganic and 20 organic COCs were detected in X-747H soils. Eleven inorganic COCs had maximum values below background and were not considered further in the analysis. Of the ten inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for four and two (cobalt and nickel) were exceeded. Soil invertebrate benchmarks were available for one of the ten inorganic COCs and it was not exceeded. Of the 20 organic COCs detected, plant toxicity benchmarks were available for seven and five (acenaphthene, anthracene, benzo[a]anthracene, benzo[a]pyrene, and dibenz(a,h)anthracene) were exceeded. Soil invertebrate benchmarks were available for two organic COCs (phenol and fluorene) and both were exceeded.

The quadrant-wide maximum soil levels for two inorganic COCs (cobalt and potassium) and 12 organic COCs (4-methylphenol, phenol, dibenzofuran, 2-methylnaphthalene, acenaphthene, acenaphthylene, benzo[k]fluoranthene, benzo[a]pyrene, chrysene, dibenz[a,h]anthracene, fluorene, and naphthalene) occurred at X-747H. 4-Methylphenol was the only chemical that was unique to SWMU X-747H in soils.

X-752 Hazardous Waste Storage Facility (X-752)

Only soil was sampled at SWMU X-752. Twenty inorganic and seven organic COCs were detected in X-752 soils. Fourteen inorganic COCs had maximum values below background and were not considered further in the analysis. Of the six inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for three and one (zinc) was exceeded. Soil invertebrate benchmarks were available for one of the six inorganic COCs and was not exceeded. Of the seven organic COCs detected, plant toxicity benchmarks were available for two (benzo[a]anthracene and

benzo[a]pyrene) and both were exceeded. Soil invertebrate benchmarks were not available for any of the seven organic COCs.

The quadrant-wide maximum soil levels for sodium occurred at X-752. No chemicals in soils were unique to SWMU X-752.

Chemical and Petroleum Containment Basins East of X-533A and Emergency Containment Tanks (CPCB)

Only soil was sampled at SWMU CPCB. Twenty inorganic and 14 organic COCs were detected in CPCB soils. Fifteen inorganic COCs had maximum values below background and were not considered further in the analysis. Of the five inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for two (lithium and zinc) and both were exceeded. Soil invertebrate benchmarks were available for one of the five inorganic COCs and it was not exceeded. Of the 14 organic COCs detected, plant toxicity benchmarks were available for four and two (benzo[a]anthracene and benzo[a]pyrene) were exceeded. Soil invertebrate benchmarks were not available for the organic COCs.

The quadrant-wide maximum soil levels for tetrachloroethene occurred at CPCB. No chemicals were unique to SWMU CPCB in soils.

North Drainage Ditch; X-230L North Holding Pond; Construction Spoils Area (NDD)

Surface-water, sediment, and soil samples were taken at NDD. In sediment, 20 organic COCs and 23 inorganic COCs were detected. Benchmarks were available for 12 inorganic COCs and 10 (arsenic, barium, cadmium, chromium, iron, lead, manganese, nickel, silver, and zinc) were exceeded. For organic COCs, benchmarks were available for 18 organic COCs and 11 (acenaphthene, anthracene, benzo[a]anthracene,

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benzo[a]pyrene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, fluoranthene, phenanthrene, and pyrene) were exceeded. The quadrant-wide sediment maximum values for six inorganic COCs (aluminum, barium, cobalt, manganese, potassium, and silver) and two organic COCs (dieldrin and chlorobenzene) occurred at NDD. Silver, dieldrin, and chlorobenzene were unique to this SWMU in sediment.

In surface water, four inorganic and eight organic COCs were detected. For inorganic COCs, benchmarks were available for all four COCs and there were two exceedences (chromium and zinc). For organic COCs, benchmarks were available for all eight COCs and there were no exceedences. Quadrant-wide maximum surface-water levels occurred at NDD for one inorganic COC (barium) and six organic COCs (1,4-dioxane, trichloroethene, 1,1,1-trichloroethane, chloromethane, cis-1,2-dichloroethene, and 2-hexanone). Five organic COCs (trichloroethene, 1,1,1-trichloroethane, chloromethane, cis-1,2-dichloroethene, and 2-hexanone) were unique to this SWMU in surface water.

In soil, one organic COC was detected in NDD soils; inorganic chemicals (except radionuclides) were not analyzed for. One radionuclide (total uranium) was present at levels above background, but plant toxicity and soil invertebrate benchmarks were not available. Soil invertebrate and plant toxicity benchmarks were also not available for the one organic COC (tetrachloroethene) detected. No quadrant-wide maximum soil concentrations occurred at SWMU NDD and no chemical was unique to this SWMU in soil.

Northeast Drainage Ditch (NEDD)

Surface-water and sediment samples were taken at NEDD. In sediment, 18 organic COCs and 22 inorganic COCs were detected. Benchmarks were available for 12 inorganic

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COCs and 12 (arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, zinc, and total cyanide) were exceeded. For organic COCs, benchmarks were available for 15 COCs and 14 (dibenzofuran, 2-methylnaphthalene, acenaphthene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, fluoranthene, naphthalene, phenanthrene, and pyrene) were exceeded. The quadrant-wide sediment maximum values for six inorganic COCs (chromium, copper, lead, mercury, zinc, and total cyanide), one radionuclide (total uranium), and 13 organic COCs (dibenzofuran, acenaphthene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, indeno[1,2,3-cd]pyrene, fluoranthene, fluorene, phenanthrene, and pyrene) occurred at SWMU NEDD. No chemicals were unique to this SWMU in sediment.

In surface water, four inorganic and eight organic COCs were detected. For inorganic COCs, benchmarks were available for all four COCs and there were two exceedences (chromium and zinc). For organic COCs, benchmarks were available for all eight COCs and there were no exceedences. Quadrant-wide maximum surface water levels occurred at NEDD for one inorganic COC (chromium) and seven organic COCs (2,4-D, 2-methylnaphthalene, acenaphthene, fluorene, naphthalene, phenanthrene, and dibenzofuran). Dibenzofuran was unique to this SWMU in surface water.

Old Northwest Firing Range (OFR)

Only soil was sampled at SWMU OFR. Eighteen inorganic and two organic COCs were detected in OFR soils. Thirteen inorganic COCs had maximum values below background and were not considered further in the analysis. Of the five inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for two (lead and zinc) and both were exceeded. Soil invertebrate benchmarks were

available for two of the five inorganic COCs and neither was exceeded. Soil invertebrate and plant toxicity benchmarks were not available for either of the organic COCs.

The quadrant-wide maximum soil levels for lead occurred at OFR. No chemicals were unique to SWMU OFR in soils.

Railroad Spur Yard Storage Area (RSY)

Only soil was sampled at SWMU RSY. Twenty-two inorganic and seven organic COCs were detected in RSY soils. Eleven inorganic COCs had maximum values below background and were not considered further in the analysis. Of the 11 inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for seven and three (arsenic, mercury, and zinc) were exceeded. Soil invertebrate benchmarks were available for five of the 11 inorganic COCs and there were no exceedences. Of the seven organic COCs detected, plant toxicity benchmarks were available for three and two (benzo[a]anthracene and benzo[a]pyrene) were exceeded. Soil invertebrate benchmarks were not available for the organic COCs. The quadrant-wide maximum soil levels for aluminum, beryllium, manganese, and chloroform occurred at RSY. Chloroform was unique to RSY in soils.

Transformer Cleaning/Storage Pad (TCP)

Only soil was sampled at SWMU TCP. Twenty-one inorganic and eight organic COCs were detected in TCP soils. Fifteen inorganic COCs had maximum values below background and were not considered further in the analysis. Of the six inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for two and one (iron) was exceeded. Soil invertebrate benchmarks were not available for the inorganic COCs. Of the eight organic COCs detected, plant toxicity benchmarks were

available for two and one (benzo[a]pyrene) was exceeded. Soil invertebrate benchmarks were not available for the organic COCs. The quadrant-wide maximum soil levels for iron and total cyanide occurred at TCP. Total cyanide was unique to TCP in soils.

Summary

Sediments were sampled at seven SWMUs (X-230J6, X-342A, X-344C/D, X-611A, X-734, NDD, and NEDD); only inorganics were analyzed for at X-611A. Benchmarks were available for most detected organic chemicals but only for about half of the detected inorganic chemicals. The number of detected chemicals ranged from 15 (X-611A) to 46 (X-230J6). One or more chemicals exceeded benchmarks at each SWMU, with the number of exceedences ranging from three (X-611A) to 27 (X-230J6). For inorganics, barium and iron exceeded benchmarks at all seven SWMUs and the number of benchmark exceedences ranged from three (X-611A) to 13 (X-230J6). For organics, the number of exceedences ranged from four (X-342A) to 14 (NEDD and X-230J6). Anthracene, benzo(g,h,i)perylene, chrysene, and pyrene exceeded benchmarks at all six SWMUs at which organics were analyzed for in sediment.

Surface water was sampled at seven SWMUs (X-114A, X-230J6, X-324A, X-344C/D, X-734, NDD, and NEDD). Benchmarks were available for all detected inorganic and organic chemicals. One or more inorganic COCs exceeded benchmarks at each SWMU, with the number of exceedences ranging from one (X-342A) to six (X-734 and X-114A). Zinc exceeded benchmarks most frequently (six of seven SWMUs). Organics were not detected in surface water at three SWMUs (X-342A, X-344C/D, and X-114A) and did not exceed benchmarks at any of the other four SWMUs.

Soils were sampled at 19 SWMUs; inorganics were not analyzed for at one of these SWMUs (NDD) and organics were not analyzed for at four SWMUs (X-114A, X-611A,

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X-735, and X-745E). More chemicals had available plant toxicity benchmarks than soil invertebrate toxicity benchmarks, although both types of benchmarks were unavailable for many chemicals. The number of detected chemicals ranged from two (NDD and X-611A) to 53 (X-333). One or more chemicals exceeded plant toxicity benchmarks at 15 SWMUs and soil invertebrate toxicity benchmarks at six SWMUs. For inorganic COCs, the number of chemicals exceeding background ranged from zero (X-611A and X-735) to 12 (X-734). The number of exceedences of plant toxicity benchmarks (for SWMUs with at least one inorganic COC detected above background) ranged from zero (X-344C/D and X-745E) to five (X-333); for soil invertebrate toxicity benchmarks, the range was zero (seven SWMUs) to two (X-630). Zinc exceeded plant toxicity benchmarks most frequently (10 of 18 SWMUs) and chromium exceeded soil invertebrate toxicity benchmarks most frequently (3 of 18 SWMUs). For organics, the number of detected chemicals ranged from one (NDD) to 32 (X-333). The number of exceedences of plant toxicity benchmarks (for SWMUs with at least one detected organic that had a benchmark value) ranged from zero (X-533A) to five (X-734, X-747H, and X-333); 12 SWMUs had at least one exceedence. For soil invertebrate toxicity benchmarks, the range was zero (four SWMUs) to two (X-747H); only two SWMUs (X-747H and X-333) had at least one exceedence. Benzo(a)pyrene and benzo(a)anthracene exceeded plant toxicity benchmarks most frequently (11 of 15 SWMUs) and phenol, 1,2,4-trichlorobenzene, and fluorene exceeded soil invertebrate toxicity benchmarks most frequently (1 of 15 SWMUs).

6.6.7.3 Magnitude of Exceedences

Tables 6.391 (sediment), 6.392 (surface water), 6.393 (plants), and 6.394 (soil invertebrates) summarize, by SWMU, the degree (magnitude) to which the maximum exposure levels for the COCs exceed the respective screening benchmarks for each environmental medium. Exceedences of screening benchmarks (ratios greater than one) infer a potential risk, indicating that further assessment of a particular chemical, medium,

and/or SWMU may be warranted as part of a more detailed analysis. In the following discussion, high exceedences and low exceedences refer to the relative magnitude of the exceedence (the degree to which the ratio exceeds one) and thus of the potential risk.

Sediment

Sediment was sampled at seven SWMUs and all seven had exceedences for inorganic COCs; all SWMUs except X-611A, at which sediments were not analyzed for organic chemicals, also had exceedences for organic COCs (Table 6.391). X-230J6 had the highest number of exceedences of both inorganic (13) and, along with NEDD, organic (14) sediment benchmarks. For inorganics, the magnitude of exceedences (all SWMUs) ranged from 1.06 to 12,000. Iron had the highest exceedence ratio at three (X-342A, X-344C/D, and X-734) of the seven SWMUs, with total cyanide (NEDD and X-230J6) and barium (NDD and X-611A) having the highest exceedence ratio at two SWMUs each. Cyanide (at NEDD) had the highest exceedence ratio (12,000) of any inorganic COC. For organics, the magnitude of exceedences (all SWMUs) ranged from 1.01 to 198,939. Anthracene had the highest exceedence ratio at all six SWMUs which were analyzed for organic chemicals. The highest exceedence ratio (198,939), for anthracene, occurred at NEDD.

Surface Water

Surface water was sampled at seven SWMUs and all seven had exceedences for inorganic COCs; there were no exceedences of organic surface-water benchmarks (Table 6.392). X-734 and X-114A had the highest number of exceedences of inorganic surface-water benchmarks (six). For inorganics, the magnitude of exceedences (all SWMUs) ranged from 1.09 to 2,615. Chromium had the highest exceedence ratio at three (NDD, NEDD, and X-230J6) of the seven SWMUs, and cadmium (at X-114A) had the highest exceedence ratio (2,615) of any inorganic COC.

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Soil - Toxicity to Plants

Soil was analyzed for inorganic chemicals at 18 SWMUs and all but four (X-344C/D, X-611A, X-735, and X-745E) had exceedences of inorganic plant toxicity benchmarks (Table 6.393). For inorganics, X-333 had the highest number (five) of exceedences. The magnitude of exceedences (all SWMUs) ranged from 2.24 to 6,500. Iron had the highest exceedence ratio at four SWMUs (TCP, X-114A, X-333, and X-630). Iron (at TCP) had the highest exceedence ratio (6,500) of any inorganic COC.

Soil was analyzed for organic chemicals at 15 SWMUs and all but three SWMUs (NDD, OFR, and X-533A) had at least one exceedence of plant toxicity benchmarks (Table 6.393). X-333, X-734, and X-747H had the highest number (five) of exceedences. The magnitude of exceedences (all SWMUs) ranged from 1.05 to 782,609. Benzo(a)anthracene had the highest exceedence ratio at 11 of the 12 SWMUs with exceedences. Benzo(a)anthracene (at X-333) had the highest exceedence ratio (782,609) of any organic COC.

Soil - Toxicity to Soil Invertebrates

Of the 18 SWMUs at which soil was analyzed for inorganic chemicals, only five (X-333, X-334, X-533A, X-630, and X-745B) had exceedences of inorganic soil invertebrate toxicity benchmarks (Table 6.394), although it should be noted that benchmark values were unavailable for many chemicals. X-630 had the highest number (two) of exceedences and the magnitude of exceedences (all SWMUs) ranged from 1.02 to 35. Chromium had the highest exceedence ratio at three of the five SWMUs, with arsenic having the highest exceedence ratio at the remaining two SWMUs. Chromium (at X-745B) had the highest exceedence ratio (35) of any inorganic COC.

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Of the 15 SWMUs at which soil was analyzed for organic chemicals, only two (X-333 and X-747H) had at least one exceedence of a soil invertebrate toxicity benchmark (Table 6.394), although it should be noted that benchmark values were unavailable for many chemicals. X-747H had the highest number (two) of exceedences. The magnitude of exceedences (all SWMUs) ranged from 2.76 to 950,000. Phenol had the highest exceedence ratio at X-747H and 1,2,4-trichlorobenzene had the highest exceedence ratio at X-333. 1,2,4-Trichlorobenzene (at X-333) had the highest exceedence ratio (950,000) of any organic COC; this was the highest exceedence of a benchmark value at any Quadrant IV SWMU for any COC in any of the environmental media sampled.

6.6.8 Conclusions

The purpose of this PERA was to assemble the existing information on: (1) the general ecology of Quadrant IV; (2) the likely exposure pathways and receptors in the area; and (3) the fate, exposure levels, and ecotoxicity of the chemicals detected in surface water, sediment, and soil. The PERA analysis is intended to screen the COCs with regard to their potential ecological risks and their likely SWMU sources. The results of the PERA provide a basis to focus subsequent analysis, such as a facility-wide and watershed-based BERA.

6.6.8.1 General Conclusions

Quadrant IV of PORTS contains 27 SWMUs, 22 of which were considered in this PERA. Soil (0 to 2 foot depth only), sediment, and surface-water samples were analyzed for a variety of inorganic and organic chemicals and radionuclides. These chemical analyses form the basis of the exposure estimates for ecological receptors, including sensitive aquatic species, and terrestrial plants and soil invertebrates. Calculated RME concentrations were compared to screening benchmarks (i.e., adverse effect levels either

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promulgated/proposed by various regulatory agencies or derived from available toxicity data) to determine if there is a potential risk to ecological receptors. Based on this screening analysis, conducted for individual SWMUs, as well as for the quadrant as a whole, the following conclusions and further considerations are presented:

- As a screening method, the PERA is based on the use of conservative ecotoxicological benchmarks that are compared to "upper bound" (i.e., 95 percent UCL or maximum) environmental levels of the various COCs. Therefore, if a COC does not exceed a benchmark, it is probable that the ecological risk from this COC is negligible. Conversely, an exceedence does not necessarily imply a serious ecological risk but does suggest that further evaluation may be warranted.

- Two types of risk assessment were performed in this PERA: quadrant-wide and SWMU-by-SWMU. Quadrant-wide RME concentrations (represented by the 95 percent UCL on the mean or the maximum detected level, whichever was less) (Tables 6.337 and 6.338) for each COC were compared to benchmark values (Table 6.390). RME concentrations (represented by the maximum detected concentration) for each COC at each SWMU were compared to the same benchmark values (Appendices H.11 and H.12).

- All samples collected from Quadrant IV are within the same watershed.

- Twenty-six inorganic COCs, 51 organic COCs, and two radionuclides were detected in at least one environmental medium (sediment, surface water, and 0-2 foot soil).

- Eleven of the 26 inorganic COCs were detected in all three media (arsenic, barium, beryllium, cadmium, chromium, cobalt, fluoride, lead, nickel, vanadium, and zinc). Twenty-five of 26 inorganic COCs were detected in sediment, 11 of 26 were detected in surface water, and 23 of 26 were detected in soil.

- Six organic COCs were detected in all three media (acenaphthene, dibenzofuran, fluorene, 2-methylnaphthalene, naphthalene, and phenanthrene). Twenty-five of the 51 organic COCs were detected in sediment, 18 of 51 were detected in surface water, and 41 of 51 were detected in soil.

- Uranium and technetium were detected in sediment and soil, but not in surface water.

- Tentative background levels were available for 20 of 23 inorganic COCs detected in soil (all except cyanide, lithium, and thallium). Quadrant-wide 95 percent UCL or maximum measured levels were less than background for 16 of the 20 inorganic COCs with background levels (Table 6.339). The four inorganic COCs that exceeded background levels were calcium, fluoride, magnesium, and sodium (Table 6.337). Background levels were not available for inorganic or radionuclide COCs in sediment or surface water. Uranium was present in some soil samples at concentrations above background. No background level exists for technetium since it is not a naturally occurring compound. Tentative background levels were not available for organic COCs.

- There were a number of COCs for which screening benchmarks were not available for a given medium (see Table 6.386). There were no SWMUs for which benchmarks were available for all detected COCs. Benchmarks were

available for 14 of 25 inorganic COCs and 21 of 25 organic COCs in sediment. Benchmarks were available for 11 of 11 inorganic COCs and 18 of 18 organic COCs in surface water. Phytotoxicity benchmarks were available for 14 of 20 inorganic COCs for which the maximum concentrations were above tentative background (SWMU by SWMU analysis), two of seven inorganic COCs for which the RME concentrations were above background (quadrant-wide analysis), and 14 of 41 organic COCs in soil. Benchmarks for soil invertebrate toxicity were available for eight of 20 inorganic COCs for which the maximum concentrations were above tentative background (SWMU by SWMU analysis), zero of seven inorganic COCs for which the RME concentrations were above background (quadrant-wide analysis), and four of 41 organic COCs in soil. No screening benchmarks were available for radionuclides in any environmental medium.

- Table 6.376 lists 32 organic COCs (out of 51 detected) that have a log K_{ow} of 3 or higher and that may have the potential to bioaccumulate through the food chain. Screening benchmarks were not available for bioaccumulation of metals or for bio-uptake of any COCs into higher plants. However, heavy metals are known to be taken up by plants and organic forms of certain metals bioaccumulate in the food chain (e.g., organo-mercury and organo-lead complexes).

6.6.8.2 Conclusions Regarding the Quadrant-Wide Analysis

The quadrant-wide analysis separates those COCs that are unlikely to present a risk to ecological receptors from those that may pose a risk based on a comparison of the RME concentration across the quadrant with suitable screening benchmark values. The potential for risk can be further defined by medium (surface water, sediment, and soil). At the PERA level of analysis, the quadrant-wide magnitude of exceedence was not considered.

Results of the quadrant-wide screen indicate that a potential ecological risk exists for 15 organic COCs; they include 13 organic COCs in sediment and six organic COCs in soil (4 as a result of exceeding phytotoxicity benchmarks and two as a result of exceeding soil invertebrate toxicity benchmarks). Nine of the 51 organic COCs may be dropped from further consideration because their RME levels were below all available benchmarks in the media in which they were detected: alpha-BHC, bromodichloromethane, chloromethane, 2,4-D, dibromochloromethane, cis-1,2-dichloroethene, dieldrin, 1,4-dioxane, and 2-hexanone. The remaining 27 organic COCs did not have exceedences, but also did not have a complete set of benchmarks and therefore could not be fully screened.

Results of the quadrant-wide screen indicate that a potential ecological risk exists for 15 inorganic COCs. Twelve inorganic COCs exceeded a benchmark in sediment, six inorganic COCs exceeded a benchmark in surface water, and one (lithium) inorganic COC exceeded a soil benchmark for phytotoxicity (none exceeded soil invertebrate benchmarks). As a result of the quadrant-wide analysis, one inorganic COC (mercury) was dropped from further consideration because its RME level was below all available benchmarks in the media in which it was detected. The remaining 10 inorganic COCs did not have exceedences, but also did not have a complete set of benchmarks and therefore could not be fully screened.

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An analysis of potential ecological risks associated with radionuclides was performed by comparing Quadrant IV uranium and technetium RME concentrations in soil, surface water, and sediment to the RME concentrations calculated in the Quadrant I/II Phase I RFIs, for which a quantitative assessment of radionuclide risks was undertaken. The analysis indicates that Quadrant IV radionuclide concentrations generally should not pose a significant risk to ecological receptors. Because the uranium RME concentration in Quadrant IV sediments was slightly higher than that calculated in the Quadrant I/II Phase I RFIs, definitive conclusions about potential ecological risks posed by sediment levels of uranium in Quadrant IV cannot be reached in this PERA. Additional consideration of the potential ecological risk posed by radionuclides appears in the BERA for the Upper Little Beaver Creek and Big Run Creek watersheds (ORNL, 1994b).

6.6.8.3 Conclusions Regarding the SWMU by SWMU Analysis

The PERA analysis of data for individual SWMUs provides a means of: (1) focusing further analysis on certain SWMUs for which potential risks may be higher, and (2) identifying sources of COCs for which potential risks exist. The table below provides a ranking of the SWMUs by their total number of exceedences and may be useful for prioritizing the analysis in a more detailed assessment, such as a BERA. An exceedence occurred at every SWMU where benchmarks were available for comparison.

Ranking of Quadrant IV SWMUs by Number of Exceedences	
SWMU	**Number of COCs Exceeded**
X-230J6	29
NEDD	28
X-734	27
NDD	23
X-344C/D	18

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Ranking of Quadrant IV SWMUs by Number of Exceedences	
SWMU	**Number of COCs Exceeded**
X-333	11
X-342	10
X-114A	9
X-747H	9
X-745B	7
X-630	6
RSY	5
CPCB	4
X-745F	4
X-334	3
X-611A	3
X-752	3
X-533A	2
OFR	2
TCP	2

6.6.8.4 Conclusions Regarding the Watershed Analysis

All of Quadrant IV can be considered one watershed. Individual watershed analyses by SWMU were not relevant to Quadrant IV.

6.6.8.5 Additional Observations

There are additional aspects of the PERA analysis that can be used to help focus and prioritize a more detailed assessment, such as a BERA. These aspects include unique

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COCs, maximum COC levels, and the number and magnitude of benchmark exceedences by COC.

- Thirty-one COCs were detected at only one SWMU (Table 6.340). An additional six COCs (2-methylphenol [o-cresol], thallium, chlorobenzene, gamma-BHC, phenol and trichloroethene) were detected at only one SWMU in a particular environmental medium, but were detected in at least two environmental media. These two groups of COCs were considered "unique" COCs. Seventy-three percent, or 27 of 37, were located in one of four SWMUs: X-333 (nine uniques), NDD (eight uniques), X-734 (seven uniques), or X-230J6 (six uniques). A total of 12 SWMUs had unique COCs. It should also be noted that, as shown in the table below, benchmarks could not be identified or developed for some of these unique COCs and, therefore, they could not be assessed for potential risk.

Unique COCs for Which Benchmarks Were Unavailable

SWMU	COC	Environmental Medium			
		Sediment	Surface Water	Soil (Plant)	Soil (Invertebrate)
X-230J6	4-Chlorophenyl-phenyl ether	X[1]			
	Selenium	X			
	Thallium	X			
X-333	2,4-Dimethylphenol			X	X
	2-Methylphenol (o-cresol)			X	X
	3/4-Methylphenol (m&p-cresol)			X	X
	Ethylbenzene			X	X
	gamma-BHC			X	X

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Unique COCs for Which Benchmarks Were Unavailable					
		Environmental Medium			
X-533A	Trichloroethene			X	X
X-734	4,4'-DDE			X	X
	Endrin ketone			X	X
	Thallium			X	X
X-745B	4-Nitroaniline			X	X
TCP	Cyanide			X	X

[1] X = COC was detected only once in the indicated medium, but no benchmark was available in that medium.

- Two SWMUs, NEDD (28 maximum values) and X-333 (20 maximum values), accounted for 32 percent (48 of 150) of the maximum detected levels for all COCs in all media combined (Tables 6.374 and 6.375).

- The COCs with the highest number of screening benchmark exceedences in the SWMU by SWMU analysis are provided in the table below. Among inorganic COCs, zinc had the greatest number of exceedences with 22 (combining all three media), followed by chromium and iron with 11, and arsenic with nine exceedences. Among organic COCs, benzo(a)anthracene had the greatest number of exceedences with 15, followed by benzo(a)pyrene with 14 exceedences. Acenaphthene, anthracene, and dibenz(a,h)anthracene all had the third highest number of exceedences with eight.

- Although magnitude of exceedence is not a deciding factor in the PERA analysis, it can provide information useful to a more detailed assessment, such as a BERA. Among inorganic COCs, the highest magnitudes of exceedence were for cyanide in sediment, cadmium in surface water, and iron in soil. Among organic COCs,

the highest magnitudes of exceedence were for anthracene in sediment and 1,2,4-trichlorobenzene in soil.

COCs with Exceedences and Number of SWMUs in Each Medium Where Exceedences Occurred			
Constituent	**Sediment**	**Surface Water**	**Soil**
INORGANICS			
Antimony	1	--[1]	--
Arsenic	4	1	4
Barium	7	0	0
Beryllium	0	1	0
Cadmium	3	1	0
Chromium	4	4	3
Cobalt	0	2	1
Copper	4	--	0
Cyanide	2	--	0
Fluoride	0	2	0
Iron	7	--	4
Lead	3	2	3
Lithium	--	--	3
Manganese	5	--	0
Mercury	3	--	4
Nickel	5	1	2
Silver	1	--	--
Vanadium	0	1	0
Zinc	6	6	10
ORGANICS			
Acenaphthene	3	0	4
Anthrancene	6	--	2
Benzo(a)anthracene	4	--	11

COCs with Exceedences and Number of SWMUs in Each Medium Where Exceedences Occurred			
Constituent	**Sediment**	**Surface Water**	**Soil**
Benzo(a)pyrene	3	--	11
Benzo(g,h,i)perylene	6	--	0
Benzo(k)fluoranthene	5	--	0
Chrysene	6	--	0
4,4'-DDT	--	--	1
Dibenz(a,h)anthracene	4	--	4
Dibenzofuran	2	0	0
Dieldrin	0	--	--
Fluoranthene	4	0	0
Fluorene	0	0	1
2-Methylnaphthalene	2	0	0
2-Methylphenol	1	--	0
Naphthalene	2	0	0
Phenanthrene	4	0	0
Phenol	1	--	1
Pyrene	6	--	0
1,2,4-Trichlorobenzene	--	--	1
[1] -- = Chemical not detected in this medium.			

Based on the PERA analysis, the following should be considered when determining the necessity for, and the scope of, more detailed analysis:

- A review of available data suggests that the terrestrial and aquatic habitats in Quadrant IV may support numerous types of wildlife indigenous to southcentral

Ohio. A more intensive survey of the habitat in Quadrant IV would be needed to determine whether it can support the threatened and endangered species listed in Table 6.335 and Appendix H.9.

- Ninety-six of 213 potential comparisons between exposure estimates and screening benchmarks could not be made because benchmarks and/or toxicity data were unavailable. Information is needed to develop screening benchmarks for these chemicals and media as part of more detailed analysis (possibly using "surrogate compounds" with available toxicity data).

- There were many instances in which the maximum measured level of a particular inorganic COC was below its tentative soil background level but above the derived benchmark. The derivation and validity of these soil benchmarks, as well as that of the background analyses, need further examination.

- There are a number of instances where plant benchmarks are based on nutrient solution values because soil concentrations were not available. Soil benchmarks based on nutrient solutions are more conservative than those based on soil concentrations, and the uncertainty about these benchmarks is considered greater than about those based on soil concentrations.

- Fraction organic carbon data (Foc) in sediment were not available for use in the PERA. Therefore, a value of 4 percent was assumed based on Mackay et al. (1992). Because Foc is used to estimate sediment benchmarks, an assumed value of 4 percent organic carbon may either under or overestimate benchmark values for PORTS, depending on whether the actual Foc in PORTS sediment is lower or higher than that assumed here.

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6.7 Risk-Based Remedial Action Objectives (RAOs)

6.7.1 Introduction

The purpose of this section is to develop human health risk-based remedial action objectives (RAOs), which can be used as chemical-specific concentration targets during the analysis and selection of remedial alternatives at the PORTS facility.

RAOs are chemical-specific concentrations in a given medium and for a specific land use (or exposure scenario) that correspond to a noncancer HI of one and excess cancer risks of 10^{-4} and 10^{-6} for all exposure pathways combined for that medium. These RAOs are similar to the preliminary remediation goals (PRGs) described in RAGS Part B (U.S. EPA, 1991b). Both RAOs and PRGs are concentration goals for individual chemicals for specific medium and land use combinations. However, RAOs, as developed for the PORTS facility, and PRGs differ in two significant ways. Whereas PRGs have been developed for only a limited number of potential exposure pathways (see U.S. EPA, 1991b, Exhibit 2-1), RAOs have been developed based on all the exposure pathways considered in the BRA for Quadrant IV of PORTS. Also, PRGs may be based on either applicable or relevant and appropriate requirements (ARARs) or on risk-based calculations, whereas RAOs, as defined here, are risk-based only. It is important to note that RAOs, like PRGs, are targets only and do not establish that clean-up to these levels is necessarily warranted.

RAOs specific to ecological endpoints have not been developed as part of this RFI. The ecological benchmarks developed in the PERA are to be used for purposes of screening only, and are not intended to serve as target clean-up levels. Preliminary remedial action goals (PRGs) have been developed in the BERA for the reaches of Upper Little Beaver

Creek and Big Run Creek (ORNL, 1994b). The reader is referred to the BERA for further discussion of PRGs based on ecological considerations.

The remainder of this section presents the methodology for calculating human health RAOs at PORTS through use of examples, identifies RAOs for the chemicals and radionuclides present in media at the PORTS facility that pose the greatest potential risks to human health, and provides observations on the alternative RAOs developed under different land use (exposure) scenarios.

6.7.2 Methodology for Calculating RAOs

The development of RAOs parallels the quantitative assessment of risks in the human health BRA for the PORTS facility. The RAOs have been calculated for chemicals of potential concern present in groundwater, soil, sediment, and surface water at PORTS. These chemicals of potential concern in the various media are identified in Section 6.2. The exposure scenarios and pathways considered in the development of RAOs are those outlined in Section 6.3 and summarized in Section 6.7.2.1 below. The toxicity values used to calculate RAOs are provided in Section 6.4.

6.7.2.1 Exposure Scenarios for RAOs

For the various media, RAOs have been calculated based on the same potential current and future on-site land uses considered in the BRA (i.e., worker, resident, excavation worker, and recreational population). The exposure pathways used to calculate RAOs are summarized in the following table.

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Exposure Pathways for the Development of RAOs				
	Population			
Media	Worker	Resident	Excavation Worker	Recreational Population
Groundwater	Ingestion Dermal contact Inhalation of vapors	Ingestion Dermal contact Inhalation of vapors	-	-
Soil	Ingestion Dermal contact External radiation Inhalation of vapors	Ingestion Dermal contact External radiation Inhalation of vapors Ingestion of vegetables Ingestion of beef Ingestion of milk	Ingestion Dermal contact External radiation Inhalation of vapors Inhalation of particulates	Ingestion of game
Sediment	Ingestion Dermal contact	-	-	Ingestion Dermal contact
Surface Water	Ingestion Dermal contact	-	-	Ingestion Dermal contact

6.7.2.2 Equations for Calculating RAOs

Risk-based RAOs are calculated by solving the risk equations for the concentration term. Because the equations used to calculate risks from noncarcinogens, chemical carcinogens, and the carcinogenic effects of radionuclides differ (see Section 6.5.2), the general procedures for calculating RAOs for each of these classes of compounds are presented below. The procedures for calculating RAOs are illustrated by the equation for calculating potential risk via ingestion of groundwater by a residential population.

In these equations, the target excess cancer risk is typically set at 10^{-4} to 10^{-6} and the target HQ is set at 1. Because risk is generally linear with respect to exposure concentration, the RAO for a target excess cancer risk of 10^{-4} would be two orders of

magnitude greater than the RAO calculated for a target excess cancer risk of 10^{-6}. RAOs are calculated to be protective of noncarcinogenic and carcinogenic effects independently; therefore, where a noncancer RfD and a cancer SF have been developed for a single chemical, the smaller of the two RAO values is selected.

6.7.2.2.1 RAO Equation for Noncarcinogens

The RAO for a noncarcinogen is calculated by combining the appropriate oral RfD or inhalation RfC with the intake, setting the HQ equal to one, and solving the equation for the concentration term. This procedure is illustrated below for the pathway of residential ingestion of groundwater.

$$HQ = \frac{Intake\ from\ oral\ ingestion}{RfD_o} = \frac{CW \times IR \times EF \times ED}{RfD_o \times BW \times AT}$$

$$CW = \frac{HQ \times RfD_o \times BW \times AT}{IR \times EF \times ED}$$

Parameters	Definition	RME Value
HQ	Hazard Quotient (unitless)	1
RfD_o	Oral Reference Dose (mg/kg/day)	chemical specific
CW	Chemical concentration in groundwater (mg/L)	-
IR	Ingestion rate (L/day)	2
EF	Exposure frequency (days/yr)	350
ED	Exposure duration (yrs)	30
BW	Body weight (kg)	70
AT	Averaging time (days)	10,950

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6.7.2.2.2 RAO Equation for Chemical Carcinogens

The RAO for a chemical carcinogen is calculated by combining the appropriate oral cancer slope factor or inhalation unit risk with the intake, setting a target excess cancer risk level, and solving the equation for the concentration term. This procedure is illustrated below, as before, with the pathway of residential ingestion of groundwater.

$$Risk = SF_o \times Intake\ from\ ingestion\ of\ water = \frac{SF_o \times CW \times IR \times EF \times ED}{BW \times AT}$$

$$CW = \frac{Risk \times BW \times AT}{SF_o \times IR \times EF \times ED}$$

Parameters	Definition	RME Value
Risk	Target excess cancer risk (unitless)	10^{-4} to 10^{-6}
SF_o	Oral cancer SF $(mg/kg/day)^{-1}$	chemical specific
CW	Chemical concentration in groundwater (mg/L)	-
IR	Ingestion rate (L/day)	2
EF	Exposure frequency (days/yr)	350
ED	Exposure duration (yrs)	30
BW	Body weight (kg)	70
AT	Averaging time (days)	25,550

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6.7.2.2.3 RAO Equation for Radionuclides

The RAO for the carcinogenic effect of a radionuclide is calculated by combining the appropriate cancer SF with the intake, setting a target excess cancer risk level, and solving the equation for the concentration term. This procedure is illustrated below, as before, with the pathway of residential ingestion of groundwater.

$$Risk = SF \times Intake = SF \times AW \times IR \times EF \times ED$$

$$AW = \frac{Risk}{SF \times IR \times EF \times ED}$$

Parameters	Definition	RME Value
Risk	Target excess cancer risk (unitless)	10^{-4} to 10^{-6}
SF	Cancer SF $(pCi)^{-1}$	chemical specific
AW	Concentration in groundwater (pCi/L)	-
IR	Ingestion rate (L/day)	2
EF	Exposure frequency (days/yr)	350
ED	Exposure duration (yrs)	30

6.7.2.2.4 RAO Equation for Multiple Exposure Pathways

Under most land use scenarios, potential risks associated with a given medium (e.g., groundwater or soil) are due to exposure via multiple pathways. For example, exposure to groundwater under the residential scenario could occur via ingestion, dermal contact, and inhalation of volatile constituents while showering. RAOs are therefore calculated by considering the cumulative exposure resulting from all potential exposure pathways

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evaluated quantitatively in the BRA. The procedure for calculating RAOs involving more than one exposure pathway is illustrated below for residential use of groundwater, and specifically, for chemical carcinogens present in groundwater. Equations can be similarly developed for noncarcinogens and radionuclides.

TotalRisk from Water = Risk from ingestion of water + Risk from dermal contact with water (showering) + Risk from inhalation of volatiles (showering)

$$= (SF_o \times CW \times EF_o) + (SF_d \times CW \times EF_d) + (SF_i \times CW^* \times EF_i)$$

$$= CW\ [(SF_o \times EF_o) + (SF_d \times EF_d) + (SF_i \times EF_i)]$$

$$CW = \frac{Total\ Risk}{(SF_o \times EF_o) + (SF_d \times EF_d) + (SF_i \times EF_i)}$$

where:

CW	=	Concentration in groundwater (mg/L)
CW^*	=	Air concentration as a function of groundwater concentration (see Appendix H.7)
Risk	=	Target excess cancer risk
SF_o	=	Oral cancer SF $(mg/kg\text{-}day)^{-1}$
SF_d	=	Dermal cancer SF $(mg/kg\text{-}day)^{-1}$
SF_i	=	Inhalation cancer unit risk $(\mu g/m^3)^{-1}$
EF_o	=	Oral exposure factors [(IR x EF x ED)/(BW x AT)]
EF_d	=	Dermal exposure factors [(SA x PC x ET x EF x ED)/(BW x AT)]
EF_i	=	Inhalation exposure factors [(FE x EF x ED)/AT]
IR	=	Ingestion rate (L/day)
SA	=	Skin surface area available for contact (cm^2)
PC	=	Dermal permeability coefficient (cm/hr)
ET	=	Exposure time (hrs/day)
FE	=	Fraction of day exposed (unitless)
EF	=	Exposure frequency (days/yr)
ED	=	Exposure duration (yrs)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

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6.7.2.2.5 Alternative Methodology for Calculating RAOs

Because risks are directly proportional to intake, and thereby, concentration, the following ratio applies for a given chemical:

$$\frac{\textit{Risk at concentration } X}{\textit{concentration } X} = \frac{\textit{Risk at concentration } Y}{\textit{concentration } Y}$$

Once a concentration and its corresponding risk are known, this ratio can be used to calculate the RAO for a target risk. Because the risks associated with a unit concentration have been calculated as part of the BRA, the above ratio can be modified to take the following form:

$$\frac{\textit{"Unit" Risk}}{\textit{Unit Concentration}} = \frac{\textit{Target Risk}}{\textit{RAO (for a single exposure pathway)}}$$

$$\textit{RAO (for a single exposure pathway)} = \frac{\textit{Target Risk}}{\textit{"Unit" Risk}} \times \textit{Unit Concentration}$$

where:

Target Risk	=	Excess cancer risk (e.g., 10^{-4} or 10^{-6}) or noncancer HQ of 1 (unitless)
"Unit" Risk	=	Excess cancer risk or HQ associated with a unit concentration (unitless)
Unit Concentration	=	Concentration in the environmental medium of concern (i.e., 1 mg/L in water, or 1 mg/kg in soil or sediment)

This ratio approach, which was used to calculate the RAOs in this assessment, is mathematically equivalent to the approach described in Sections 6.7.2.2.1 to 6.7.2.2.4. Application of the ratio approach is illustrated below for carcinogens and noncarcinogens. If the excess cancer risk for a given chemical and given exposure pathway associated with

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a unit concentration (1 mg/kg) in soil is 2×10^{-5}, the RAO associated with a target excess cancer risk of 10^{-6} is calculated as:

$$RAO = \frac{10^{-6}}{2 \times 10^{-5}} \times 1\ mg/kg = 0.05\ mg/kg$$

Similarly, for a HQ of 3×10^{-2} associated with a unit groundwater concentration (1 mg/L), the RAO associated with a target HQ of 1 is calculated as:

$$RAO = \frac{1}{3 \times 10^{-2}} \times 1\ mg/L = 33\ mg/L$$

The above equations apply to single exposure pathways only. To develop an RAO that takes into consideration all relevant pathways, the RAO for a given population and a given medium can be determined from the following equation:

$$Risk\text{-}based\ RAO = \left(\frac{1}{RAO_o} + \frac{1}{RAO_d} + \frac{1}{RAO_i} + \ldots + \frac{1}{RAO_n} \right)^{-1}$$

where:	RAO_o	=	target concentration based on the oral pathway
	RAO_d	=	target concentration based on the dermal contact pathway
	RAO_i	=	target concentration based on the inhalation pathway
	RAO_n	=	target concentration based on the n^{th} pathway

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6.7.3 Summary of Risk-Based RAOs for Driver Chemicals and Radionuclides

RAOs are presented in Tables 6.395 to 6.398 for the "driver" chemicals in the various media as identified in Section 6.5 (i.e., chemicals and radionuclides with excess cancer risks greater than 10^{-6} or HQ values of one or greater). Detailed tables listing the RAOs for all the chemicals detected in the various media can be found in Appendix H.13.

6.7.4 Conclusions and Observations

It is important to note that RAOs are calculated for individual chemicals by exposure medium and by exposure pathway. RAOs do not account for potential cumulative effects of exposure to multiple chemicals in a single medium, nor to exposure to a single chemical in multiple media. Also, RAOs are based solely on the protection of human health; potential ecological effects are not considered in the development of RAOs. It should be further noted that RAOs were derived without consideration for analytical detection limits. In fact, the RAOs for some chemicals (e.g., PCBs) are lower than available methods can detect. PQLs to which RAOs can be compared are found in Section 6.2.4.

Upon inspection of the tables in Appendix H.13, the following observations can be made:

- For constituents for which both a noncancer RfD and cancer SF have been developed, the RAO calculated using a target excess cancer risk of 10^{-6} is, in all cases, lower than the RAO calculated using a noncancer HQ of 1. Where the target excess cancer risk is set at 10^{-4}, the RAO based on the analysis of noncancer effects is sometimes lower. Therefore, while application of RAOs

based on carcinogenic effects are generally protective, consideration should also be given to RAOs based on noncancer effects.

Groundwater

- RAOs for groundwater have been developed for both worker and residential exposure scenarios. Because the residential scenario results in greater potential exposures, the RAOs for the residential scenario are smaller than those for the worker scenario.

- The RAOs for the majority of the chemical constituents are driven by ingestion, assuming the groundwater to be a potential future drinking water source. For a few volatile chemicals, inhalation of vapors (during showering) is a significant exposure pathway. In fact, for carbon disulfide, chlorobenzene, chloroform, dichlorodifluoromethane, and 1,1,2-trichloro-1,2,2-trifluoroethane, inhalation of vapors is the dominant pathway in determining the groundwater RAO.

Soil

- RAOs for soil have been developed for worker, residential, excavation worker, and recreational exposure scenarios. For most chemicals, the RAOs for residential land use conditions are the lowest. For those constituents that are relatively lipid soluble (e.g., PCBs, PAHs, and the pesticides gamma-chlordane, 4,4'-DDE, and 4,4'-DDT) and for some inorganic compounds, notably fluoride, mercury, selenium, silver, thallium, and technetium, inclusion of the beef and milk ingestion pathways substantially reduces the RAOs. For example, for Aroclor-1260, the inclusion of the beef and milk pathways reduces the RAO

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(based on an excess cancer risk of 10^{-6}) by about 50-fold, from 4×10^{-2} mg/kg without beef and milk ingestion to 9×10^{-4} mg/kg when beef and milk ingestion are included. Because in the human health BRA, potential risks associated with these exposure pathways were based on quadrant-wide average soil concentrations, an RAO driven by ingestion of beef and milk may not provide information useful to an evaluation of remedial alternatives for individual SWMUs.

- For some constituents, the excavation scenario yields the lowest RAO of the exposure scenarios modeled. Where this occurs for organic constituents in soil, the RAO is generally driven by the modeled exposures associated with inhalation of soil vapors. It is important to note that there are many uncertainties and conservative assumptions in the model used to estimate vapor concentrations. Therefore, the RAOs derived from this pathway should be interpreted with caution.

- The risk assessment for the recreational population demonstrates that average constituent concentrations across the quadrant do not present significant risks based on indirect exposures to constituents in soil from consumption of game that feed on the site. Furthermore, the RAOs protective of the recreational population are generally several orders of magnitude greater than the RAOs based on residential exposures.

- Because the conditions of exposure assumed under the residential scenario result in the lowest RAOs, the following observations related to residential exposure pathways are offered:

- Dermal contact with soil drives the RAO for many of the organic and inorganic compounds. For organic compounds, the RAO derived for dermal contact was 1.5 to 10 times smaller than the RAO for soil ingestion, and for many inorganic compounds, the RAO was four to 15 times smaller. For PCBs, incidental ingestion of soil and dermal contact with soil are comparable. The relative significance of dermal contact as a contributor to exposure is influenced directly by the dermal absorption factor (i.e, the percentage of chemical in soil adhered to skin that is assumed to be absorbed dermally). The uncertainties about this factor and resultant estimates of exposure are discussed in Section 6.5.4.1.

- Ingestion of vegetables contributes significantly to the RAOs for several organic and inorganic constituents. However, because of uncertainties inherent in the vegetable uptake model, the same cautions in interpreting RAOs resulting from the excavation vapor model should also hold for these vegetable-derived RAOs.

- External gamma radiation drives the RAOs for uranium-235 and uranium-238. For technetium, the indirect pathways involving foodchain bioaccumulation, including ingestion of vegetables, beef, and milk drive the RAO.

Sediment and Surface Water

- RAOs for sediment and surface water have been developed for worker and recreational scenarios. For most chemicals, the surface water and sediment RAOs based on the recreational scenario are the lower of the two, although RAOs differ by only about two-fold.

- For organic chemicals (with the exception of PCBs), the pathway that drives the sediment RAO is dermal contact. See Section 6.5.4.1 for a discussion of the uncertainties associated with the dermal pathway. RAOs for PCBs based on the ingestion and dermal contact pathways are comparable. For inorganic compounds, either incidental ingestion or dermal contact may be the more significant pathway. Both incidental ingestion and dermal contact with surface-water influence derivation of the surface-water RAO.

6.8 Conclusions

6.8.1 Human Health BRA

6.8.1.1 Introduction

A human health baseline risk assessment (BRA) was conducted to support risk-based decisions regarding the need for further action at SWMUs in Quadrant IV. In performing this BRA, assessment of potential risk were conducted for each SWMU (see exceptions noted below) and, under selected scenarios, for the quadrant as a whole based on a set of reasonable maximum exposure (RME) assumptions. Discussions of the risk assessment findings for the SWMU-specific and quadrant-wide assessments are presented in

Sections 6.8.1.3 and 6.8.1.4 below. Because some portions of the inorganic constituents present in environmental media are naturally occurring, an assessment was performed of potential risks associated with naturally occurring constituents at tentative background levels in order to distinguish these potential risks from those that may be related to activities at the PORTS facility. The results of the background risk assessment are summarized in Section 6.8.1.2.

Risk assessments were performed for 24 of the 27 SWMUs in Quadrant IV. Because of the spacial distribution of the sampling locations for three SWMUs, the Recirculating Cooling Water System (RCW), the Sanitary Sewer System (SASW) and the Storm Sewer System (STSW), SWMU-specific assessments were considered inappropriate. Data from these SWMUs were included, however, in the assessment based on quadrant-wide average concentrations.

6.8.1.2 Background Risks

Background levels of naturally occurring compounds in soils (based on an analysis of tentative background values) pose potentially significant health risks (i.e., noncancer HI greater than one or excess cancer risk greater than 10^{-6}) for all future on-site exposure scenarios evaluated (i.e., future on-site worker, resident, excavation worker, and recreational population). Potential excess cancer risks associated with exposure to soil constituents at tentative background levels under these various future use scenarios are in the range of 10^{-4} to 10^{-6}; these risks are largely attributable to arsenic and beryllium.

A background analysis has not been performed for groundwater, sediment, or surface-water. As discussed below, however, background levels of inorganic or other non-plant related constituents in these media may contribute to the overall estimates of potential risk

derived for each of the SWMUs. Risks associated with inorganic constituents and radiological parameters in soil and groundwater will be re-evaluated using the background analysis presented in the BSI, and results of this reanalysis will be addressed in the CAS/CMS.

6.8.1.3 SWMU-Specific RME Risks

6.8.1.3.1 Groundwater and Soil Media

Potential risks under current and future land use conditions for each of the SWMUs considered in the Quadrant IV BRA based on an assessment of soil and groundwater data are discussed in Section 6.5.3.4 and summarized below. Assessments of each SWMU for which groundwater and/or soil data were collected were performed for a current and future on-site worker, a future on-site resident, and an excavation worker. The categorization of SWMUs into one of three risk groups (see below) is based on the scenario involving a reasonable maximum exposure of a hypothetical future on-site resident.

The assessment of total potential risks for the future on-site worker and residential populations is based on data for groundwater from the Gallia aquifer only. A separate assessment of potential risks associated with constituents in the Berea aquifer was conducted; the findings of this assessment are summarized later in this section.

Noncancer HI values and excess cancer risk levels for a future on-site resident, by SWMU and by medium, are presented schematically in Figures 6.5 and 6.6. Additional figures for the future worker, current worker, and excavation worker scenarios are presented in Figures 6.7 to 6.12. To differentiate between potential risks attributable to constituents in groundwater (Gallia aquifer) and soil, figures have been prepared presenting

potential risks associated with both media, with constituents in groundwater only, and with constituents in soil only.

The assessment of potential residential risks for each SWMU as presented in Section 6.5.4.3 of the BRA considers potential exposures to constituents in a given SWMU as well as exposures calculated using quadrant-wide average concentrations (i.e., exposures associated with beef and milk ingestion and with recreational activities). To support the CMS, the following discussions of residential risk for each SWMU, however, are based only on potential risks associated with constituents present in the specific SWMU.

Based on the analysis of SWMU-specific risks associated with groundwater (Gallia aquifer) and soil, SWMUs were categorized into one of three general groups based on potential carcinogenic and noncarcinogenic risk as follows:

Target Risk Levels Not Exceeded. SWMUs in this group pose negligible potential carcinogenic risk (less than 10^{-6}) and negligible potential noncarcinogenic risk (HI less than one) in all exposure scenarios modeled. Four SWMUs fall into this group:

- X-114A Firing Range (X-114A)
- X-344A Uranium Hexafluoride Sampling Facility/Settling Tank (X-344A)
- X-745E Northwest International Process Gas Yard (X-745E)
- Old Northwest Firing Range (OFR)

In considering the nature of potential risks posed by these four units, it should be noted that estimated risks for X-114A, X-745E, and OFR were based only on constituents present in soil; groundwater samples were not taken at these units. Thus, to the extent that constituents in groundwater, either site-related or non-site-related, contribute to total risk,

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the total estimated risk at these three SWMUs may be underestimated. For X-344A, only one groundwater sample was collected and soil samples were not collected. Therefore, pathways involving potential future exposure to soil were not considered in the risk assessment for this SWMU. Finally, the focus of the assessment of the X-114A Firing Range was possible lead contamination of surface soils. Lead levels at this unit did not present unacceptable risks.

Within Target Risk Levels. SWMUs in this group pose potential carcinogenic risks within the U.S. EPA range of concern (between 10^{-6} and 10^{-4}). Three SWMUs fall into this group:

- X-334 Transformer Storage and Cleaning Building (X-334)
- X-611A North, Middle, and South Lime Sludge Lagoons (X-611A)
- Chemical and Petroleum Containment Basins East of X-533A (CPCB) and Emergency Containment Tanks (CPCB)

In considering the nature of potential risks posed by these three units, it should be noted that estimated risks for the CPCB unit are based only on constituents present in soil; groundwater samples were not taken at this unit. Thus, to the extent that constituents in groundwater, either site-related or non-site-related, contribute to total risk, the total estimated risk at this unit may be underestimated.

Target Risk Levels Exceeded. SWMUs in this group pose significant potential carcinogenic risk (greater than 10^{-4}) or significant potential noncarcinogenic risk (HI greater than one) in one or more exposure scenarios modeled. Seventeen SWMUs fall into this group:

- X-230J6 Northeast Holding Pond, Monitoring Facility, and Secondary Oil Collection Basin (X-230J6)
- X-333 Process Building (X-333)
- X-342A Feed Vaporization and Fluorine Generation Building; X-342B Fluorine Storage Building; X-342C Waste HF Neutralization Pit (X-342)
- X-344C HF Storage Facility; X-344D HF Neutralization Pit (X-344C/D)
- X-533A Switchyard; X-533B Switch House; X-533C Test and Repair Building; X-533D Oil House and Associated French Drains; X-533E Valve House; X-533F Valve House; X-533H Gas Reclaiming Cart Garage (X-533A)
- X-630-1 Recirculating Water Pump House; X-630-2A Cooling Tower; X-630-2B Cooling Tower; X-630-3 Acid Handling Station (X-630)
- X-734 Old Sanitary Landfill; X-734A Construction Spoils Landfill; X-734B Old Construction Spoils Landfill (X-734)
- X-735 Sanitary Landfill and X-735A Landfill Utility Building (X-735)
- X-744W Surplus and Salvage Warehouse (X-744W)
- X-745B Enrichment Process Gas Yard (X-745B)
- X-745F North Process Gas Stockpile Yard (X-745F)
- X-747H Northwest Surplus and Scrap Yard (X-747H)
- X-752 Hazardous Waste Storage Facility (X-752)
- North Drainage Ditch (NDD); X-230L North Holding Pond; Construction Spoils Area (NDD)
- Northeast Drainage Ditch (NEDD)
- Railroad Spur Yard Storage Area (RSY)
- Transformer Cleaning/Storage Pad (TCP)

Where groundwater wells in the Gallia aquifer are located in the vicinity of a SWMU and future domestic use of groundwater from these wells was assumed, potential risks

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associated with constituents in groundwater for these 17 units generally drive the total risks. It should be noted that risks are in large part attributable to constituents that may occur naturally. Risks associated with inorganic constituents and radiological parameters in groundwater will be re-evaluated using the background analysis presented in the BSI, and results of this reanalysis will be addressed in the CAS/CMS.

Arsenic in soil or Gallia groundwater is one of the most significant contributors to overall risk in 16 of the 17 SWMUs that exceed target risk levels. In addition to arsenic, other inorganic compounds (including beryllium, cadmium, chromium, nickel, thallium, uranium, vanadium, and zinc) in groundwater from the Gallia aquifer and soil contribute significantly to the potential cancer and noncancer risks associated with a number of the SWMUs. Because of the significance of risks posed by inorganic constituents in PORTS media and because even tentative background levels of arsenic and beryllium in soil at PORTS also pose a significant risk, further consideration of health risks associated with naturally occurring constituents at background levels is recommended before remedial actions are proposed. Remedial decisions should also take into consideration the degree of uncertainty in the arsenic cancer SF articulated by U.S. EPA in IRIS (U.S. EPA, 1994a). The Administrator of the U.S. EPA has counseled that "In reaching risk management decisions in a specific situation, risk managers must recognize and consider the qualities of risk estimates. The uncertainties associated with ingested inorganic arsenic are such that estimates could be modified downwards by as much as an order of magnitude, relative to risk estimates associated with most other carcinogens" (U.S. EPA, 1994a).

Technetium does not pose a significant risk in any Quadrant IV SWMU. Uranium isotopes in soil pose risks greater than 10^{-6} in eight Quadrant IV SWMUs. These SWMUs are X-344C/D, X-734, X-745B, X-745F, X-747H, NDD, NEDD, and TCP. In all cases, the exposure pathway that contributed most significantly to risk was external radiation

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exposure to uranium isotopes in soil. With the exception of X-745B and TCP, potential excess cancer risks associated with external radiation exposure range from one to 2 x 10^{-6} due to maximum detected uranium concentrations that exceed the tentative background soil concentration for uranium (4.89 mg/kg) by only 1.5- to 3.5-fold. Potential excess cancer risks associated with external radiation at the TCP and X-745B units are 6 x 10^{-6} and 5 x 10^{-5}, respectively.

Organic constituents in soil and groundwater pose a potentially significant risk (noncancer HI greater than one or excess cancer risk greater than 10^{-6}) in some of the SWMUs under the conditions modeled in this BRA. PCBs in soil present a potentially significant risk in SWMUs X-333, X-533A, X-630, X-734, X-744W, X-745B and TCP. PAHs in soil present a potentially significant risk in SWMUs X-333, X-334, X-342, X-630, X-734, X-744W, X-745B, X-745F, X-747H, CPCB, NDD, NEDD, and RSY. In the X-333, X-611A, X-630, and X-734 units, chlorinated hydrocarbon compounds in groundwater (Gallia aquifer) also pose excess cancer risks greater than 10^{-6}. Other organic constituents that pose potential excess cancer risks greater than 10^{-6} include the following: chloroform in the soil of SWMU RSY, bromoform in the soil of SWMU TCP, and 1,4-dioxane in the groundwater of SWMU X-734.

As noted above, a separate assessment was performed for groundwater from the Berea aquifer. This assessment shows that potentially significant risks (noncancer HI greater than one or excess cancer risk greater than 10^{-6}) are due primarily to arsenic. Exposure to beryllium, chromium, vanadium, benzene, and 1,1,2,2-tetrachloroethane also pose potentially significant risks. Because an analysis taking into account approved background levels of naturally occurring or other non-plant-related constituents in groundwater from the Gallia or Berea aquifer was not performed as part of this BRA, it is not possible to differentiate between potentially site-related risks and risks attributable to background. As

stated previously with respect to groundwater from the Gallia aquifer, remedial decisions should take into consideration the extent to which background levels of naturally occurring inorganic constituents contribute to total risk and the degree of uncertainty in the cancer assessment for arsenic.

Under the current use scenario for an on-site worker, target risk levels (i.e., noncancer HI greater than one or excess cancer risk level greater than 10^{-4}) are exceeded only at SWMUs X-333, X-734 and X-747H. At these units, excess cancer risks are principally associated with PCBs, PAHs, arsenic, and beryllium in 0 to 2 foot soils. Potential excess cancer risk levels between 10^{-6} and 10^{-4} for the current on-site worker are posed by exposure to media at SWMUs X-533A, X-630, X-745B, X-745F, CPCB, RSY, and TCP. It should be noted that shallow soil data (i.e., 0 to 2 feet) upon which the current use scenario was based were not available for SWMUs X-230J6, X-342, X-344A, X-744W, and NEDD.

6.8.1.3.2 Sediment and Surface-Water Media

Potential risks under current and future land use conditions for each of the SWMUs considered in the Quadrant IV BRA based on an assessment of RFI data for sediment and/or surface water are discussed in Section 6.5.3.4 and summarized below. Assessments of each SWMU for which sediment and surface-water data were collected were performed for an on-site worker and a future on-site recreational population. Noncancer HI values and excess cancer risk levels for worker and recreational scenarios are presented in Figures 6.13 to 6.16. The summary below is limited to the scenario involving a reasonable maximum exposure of a hypothetical future on-site recreational population. In general, the RME recreational population exposure represents a conservative characterization of potential risk associated with the constituents present in these media.

Based on the analysis of SWMU-specific risks associated with sediment and surface water, SWMUs were categorized into one of three general groups based on potential carcinogenic and noncarcinogenic risk as follows:

Target Risk Levels Not Exceeded. SWMUs in this group pose negligible potential carcinogenic risk (less than 10^{-6}) and negligible potential noncarcinogenic risk (HI less than 1) in all exposure scenarios modeled. No SWMUs fall into this group.

Within Target Risk Levels. SWMUs in this group pose potential carcinogenic risks within the U.S. EPA range of concern (between 10^{-6} and 10^{-4}). Four SWMUs fall into this group:

- Seep samples from the X-114A Firing Range (X-114A)
- X-342C Waste HF Neutralization Pit (X-342C)
- X-344D HF Neutralization Pit (X-344D)
- Shallow sediment from the X-611A North, Middle, and South Lime Sludge Lagoons (X-611A)

The sediment and surface-water samples upon which the assessments of the X-342C and X-344D units were based came from the X-342C and X-344D Neutralization Pits; therefore, the assessments conducted here for these two units reflects contaminant conditions within the pits only.

Target Risk Levels Exceeded. SWMUs in this group pose significant potential carcinogenic risk (greater than 10^{-4}) or significant potential noncarcinogenic risk (HI greater than 1) in one or more exposure scenarios modeled. Five SWMUs fall into this group:

- X-230J6 Northeast Holding Pond and Secondary Oil Collection Basin (X-230J6)

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- Deep sediment from the X-611A North, Middle, and South Lime Sludge Lagoons (X-611A)
- Seep samples from the X-734 Old Sanitary Landfill (X-734)
- North Drainage Ditch and X-230L North Holding Pond (NDD)
- Northeast Drainage Ditch (NEDD)

It should be noted that naturally occurring inorganic constituents contribute significantly to total potential risks associated with all the SWMUs with estimated potential cancer risks in excess of 10^{-6}. Because background levels of naturally occurring or other non-plant-related constituents in sediment and surface water have not yet been established, it is not possible to differentiate between potentially site-related risks and risks attributable to background.

Arsenic in sediment is one of the most significant contributors to overall risk in all nine of these SWMUs with risks greater than 10^{-6}. In addition to arsenic, beryllium contributes significantly to the potential cancer and noncancer risks in the seep at X-114A, and the sediment of X-230J6, X-611A, X-734, NDD, and NEDD. Chromium in sediment is also a significant contributor at X-230J6, X-611A, and NEDD, as is manganese in sediment at X-611A and NDD. As stated previously with respect to soil and groundwater, remedial decisions should take into consideration the extent to which background levels of naturally occurring inorganic constituents contribute to total risk and the degree of uncertainty in the cancer assessment for arsenic.

Organic constituents in sediment that pose a potentially significant excess cancer risk (greater than 10^{-6}) are PAHs in the sediment of SWMUs X-230J6, X-342C, X-344D, X-734, NDD, and NEDD, and PCBs in the sediment of X-230J6 and X-611A. Neither

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technetium nor uranium posed significant risks in the sediment or surface-water of any SWMU in Quadrant IV.

6.8.1.3.3 Incremental Risks

Because naturally occurring inorganic compounds in PORTS media present a risk of their own, an incremental risk assessment was performed to distinguish that portion of total risk likely attributable to naturally occurring background from that portion of the risk likely attributable to facility operations. Incremental risks were calculated by subtracting risks associated with background levels of naturally occurring inorganic constituents in soil from risks associated with total constituent levels. The resulting risks (i.e., incremental risks) are those associated with concentrations of constituents in excess of background.

In the assessment of incremental risks, Quadrant IV SWMUs fall into the same general risk categories as in the assessment of risks based on total constituent concentrations. It is noted, however, that the current incremental risk assessment is based only on tentative background data for soil. Consideration of the background analysis for groundwater constituents presented in the BSI may allow differentiation of background-related risks and potential facility-related risks for this medium.

6.8.1.3.4 Risks Developed using Typical Exposure Assumptions

Appendix H.4 presents risk estimates for the typical exposure assessment, which was prepared as one means of characterizing the variability or uncertainty in the exposure estimates for the scenarios considered in the Quadrant IV BRA. Although overall risk are less for the typical case than the RME case, the SWMUs fall into the same general risk categories with the following exceptions:

- SWMU X-334 transfers from the risk category "Within Target Risk Levels" to "Target Risk Levels Not Exceeded."

- SWMUs X-745, NEDD (groundwater/soil), and X-734 (sediment/surface water) transfer from the risk category "Target Risk Levels Exceeded" to "Within Target Risk Levels."

6.8.1.4 Quadrant-Wide Risks

The assessment of potential risks under current and future land use conditions based on quadrant-wide average concentrations is presented in Section 6.5.3.3. For the indirect exposure pathways of ingestion of beef and milk from cows grazed on Quadrant IV soils, PCBs, PAHs, and technetium contribute to potential excess cancer risks above 10^{-6}. For the sediment and surface-water media, similar to the assessments for individual SWMUs, risks in excess of 10^{-6} are generally associated with arsenic, beryllium, PCBs, and PAHs.

6.8.1.5 Risks Associated with Little Beaver Creek

The quantitative risk assessment for Little Beaver Creek, a major surface water feature of Quadrant IV, was conducted as part of the Quadrant II RFI; a full discussion of potential risks associated with constituents in creek surface water and sediments, fish, and floodplain soil can be found in that report.

The most significant contributors to risk associated with Little Beaver Creek media are Aroclor-1260 and PAHs in sediment, fish, and floodplain soil; arsenic and beryllium in sediment; and uranium and technetium in floodplain soil.

6.8.2 Preliminary Ecological Risk Assessment

The purpose of this PERA was to assemble the existing information on: (1) the general ecology of Quadrant IV; (2) the likely exposure pathways and receptors in the area; and (3) the fate, exposure levels, and ecotoxicity of the chemicals detected in surface water, sediment, and soil. The PERA analysis is intended to screen the COCs with regard to their potential ecological risks and their likely SWMU sources. The results of the PERA provide a basis to focus subsequent analysis, such as a facility-wide and watershed-based BERA.

6.8.2.1 General Conclusions

Quadrant IV of PORTS contains 27 SWMUs, 22 of which were considered in this PERA. Soil (0 to 2 foot depth only), sediment, and surface-water samples were analyzed for a variety of inorganic and organic chemicals and radionuclides. These chemical analyses form the basis of the exposure estimates for ecological receptors, including sensitive aquatic species, and terrestrial plants and soil invertebrates. Calculated RME concentrations were compared to screening benchmarks (i.e., adverse effect levels either promulgated/proposed by various regulatory agencies or derived from available toxicity data) to determine if there is a potential risk to ecological receptors. Based on this screening analysis, conducted for individual SWMUs, as well as for the quadrant as a whole, the following conclusions and further considerations are presented:

- As a screening method, the PERA is based on the use of conservative ecotoxicological benchmarks that are compared to "upper bound" (i.e., 95 percent UCL or maximum) environmental levels of the various COCs. Therefore, if a COC does not exceed a benchmark, it is probable that the

ecological risk from this COC is negligible. Conversely, an exceedence does not necessarily imply a serious ecological risk but does suggest that further evaluation may be warranted.

- Two types of risk assessment were performed in this PERA: quadrant-wide and SWMU-by-SWMU. Quadrant-wide RME concentrations (represented by the 95 percent UCL on the mean or the maximum detected level, whichever was less) (Tables 6.337 and 6.338) for each COC were compared to benchmark values (Table 6.390). RME concentrations (represented by the maximum detected concentration) for each COC at each SWMU were compared to the same benchmark values (Appendices H.11 and H.12).

- All samples collected from Quadrant IV are within the same watershed.

- Twenty-six inorganic COCs, 51 organic COCs, and two radionuclides were detected in at least one environmental medium (sediment, surface water, and 0 to 2 foot soil).

- Eleven of the 26 inorganic COCs were detected in all three media (arsenic, barium, beryllium, cadmium, chromium, cobalt, fluoride, lead, nickel, vanadium, and zinc). Twenty-five of 26 inorganic COCs were detected in sediment, 11 of 26 were detected in surface water, and 23 of 26 were detected in soil.

- Six organic COCs were detected in all three media (acenaphthene, dibenzofuran, fluorene, 2-methylnaphthalene, naphthalene, and phenanthrene). Twenty-five of

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the 51 organic COCs were detected in sediment, 18 of 51 were detected in surface water, and 41 of 51 were detected in soil.

- Uranium and technetium were detected in sediment and soil, but not in surface water.

- Tentative background levels were available for 20 of 23 inorganic COCs detected in soil (all except cyanide, lithium, and thallium). Quadrant-wide 95 percent UCL or maximum measured levels were less than background for 16 of the 20 inorganic COCs with background levels (Table 6.339). The four inorganic COCs that exceeded background levels were calcium, fluoride, magnesium, and sodium (Table 6.337). Background levels were not available for inorganic or radionuclide COCs in sediment or surface water. Uranium was present in some soil samples at concentrations above background. No background level exists for technetium since it is not a naturally occurring compound. Tentative background levels were not available for organic COCs.

- There were a number of COCs for which screening benchmarks were not available for a given medium (see Table 6.386). There were no SWMUs for which benchmarks were available for all detected COCs. Benchmarks were available for 14 of 25 inorganic COCs and 21 of 25 organic COCs in sediment. Benchmarks were available for 11 of 11 inorganic COCs and 18 of 18 organic COCs in surface water. Phytotoxicity benchmarks were available for 14 of 20 inorganic COCs for which the maximum concentrations were above preliminary background (SWMU by SWMU analysis), two of seven inorganic COCs for which the RME concentrations were above background (quadrant-wide analysis), and 14 of 41 organic COCs in soil. Benchmarks for soil invertebrate toxicity

were available for: eight of 20 inorganic COCs for which the maximum concentrations were above tentative background (SWMU by SWMU analysis), zero of seven inorganic COCs for which the RME concentrations were above background (quadrant-wide analysis), and four of 41 organic COCs in soil. No screening benchmarks were available for radionuclides in any environmental medium.

- Table 6.376 lists 32 organic COCs (out of 51 detected) that have a log K_{ow} of three or higher and that may have the potential to bioaccumulate through the food chain. Screening benchmarks were not available for bioaccumulation of metals or for bio-uptake of any COCs into higher plants. However, heavy metals are known to be taken up by plants and organic forms of certain metals bioaccumulate in the food chain (e.g., organo-mercury and organo-lead complexes).

6.8.2.2 Conclusions Regarding the Quadrant-Wide Analysis

The quadrant-wide analysis separates those COCs that are unlikely to present a risk to ecological receptors from those that may pose a risk based on a comparison of the RME concentration across the quadrant with suitable screening benchmark values. The potential for risk can be further defined by medium (surface water, sediment, and soil). At the PERA level of analysis, the quadrant-wide magnitude of exceedence was not considered.

Results of the quadrant-wide screen indicate that a potential ecological risk exists for 15 organic COCs; they include 13 organic COCs in sediment and six organic COCs in soil (4 as a result of exceeding phytotoxicity benchmarks and two as a result of exceeding soil invertebrate toxicity benchmarks). Nine of the 51 organic COCs may be dropped from

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further consideration because their RME levels were below all available benchmarks in the media in which they were detected: alpha-BHC, bromodichloromethane, chloromethane, 2,4-D, dibromochloromethane, cis-1,2-dichloroethene, dieldrin, 1,4-dioxane, and 2-hexanone. The remaining 27 organic COCs did not have exceedences, but also did not have a complete set of benchmarks and therefore could not be fully screened.

Results of the quadrant-wide screen indicate that a potential ecological risk exists for 15 inorganic COCs. Twelve inorganic COCs exceeded a benchmark in sediment, six inorganic COCs exceeded a benchmark in surface water, and one (lithium) inorganic COC exceeded a soil benchmark for phytotoxicity (none exceeded soil invertebrate benchmarks). As a result of the quadrant-wide analysis, one inorganic COC (mercury) was dropped from further consideration because its RME level was below all available benchmarks in the media in which it was detected. The remaining 10 inorganic COCs did not have exceedences, but also did not have a complete set of benchmarks and therefore could not be fully screened.

An analysis of potential ecological risks associated with radionuclides was performed by comparing Quadrant IV uranium and technetium RME concentrations in soil, surface water, and sediment to the RME concentrations calculated in the Quadrant I/II Phase I RFIs, for which a quantitative assessment of radionuclide risks was undertaken. The analysis indicates that Quadrant IV radionuclide concentrations generally should not pose a significant risk to ecological receptors. Because the uranium RME concentration in Quadrant IV sediments was slightly higher than that calculated in the Quadrant I/II Phase I RFIs, definitive conclusions about potential ecological risks posed by sediment levels of uranium in Quadrant IV cannot be reached in this PERA. Additional consideration of the potential ecological risk posed by radionuclides appears in the BERA for the Upper Little Beaver Creek and Big Run Creek watersheds (ORNL, 1994b).

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6.8.2.3 Conclusions Regarding the SWMU by SWMU Analysis

The PERA analysis of data for individual SWMUs provides a means of: (1) focusing further analysis on certain SWMUs for which potential risks may be higher, and (2) identifying sources of COCs for which potential risks exist. The table below provides a ranking of the SWMUs by their total number of exceedences and may be useful for prioritizing the analysis in a more detailed assessment, such as a BERA. An exceedence occurred at every SWMU where benchmarks were available for comparison.

Ranking of Quadrant IV SWMUs by Number of Exceedences	
SWMU	**Number of COCs Exceeded**
X-230J6	29
NEDD	28
X-734	27
NDD	23
X-344C/D	18
X-333	11
X-342	10
X-114A	9
X-747H	9
X-745B	7
X-630	6
RSY	5
CPCB	4
X-745F	4
X-334	3
X-611A	3

Ranking of Quadrant IV SWMUs by Number of Exceedences	
SWMU	**Number of COCs Exceeded**
X-752	3
X-533A	2
OFR	2
TCP	2

6.8.2.4 Conclusions Regarding the Watershed Analysis

All of Quadrant IV can be considered one watershed. Individual watershed analyses by SWMU were not relevant to Quadrant IV.

6.8.2.5 Additional Observations

There are additional aspects of the PERA analysis that can be used to help focus and prioritize a more detailed assessment, such as a BERA. These aspects include unique COCs, maximum COC levels, and the number and magnitude of benchmark exceedences by COC.

- Thirty-one COCs were detected at only one SWMU (Table 6.340). An additional six COCs (2-methylphenol [o-cresol], thallium, chlorobenzene, gamma-BHC, phenol and trichloroethene) were detected at only one SWMU in a particular environmental medium, but were detected in at least two environmental media. These two groups of COCs were considered "unique" COCs. Seventy-three percent, or 27 of 37, were located in one of four SWMUs: X-333 (nine uniques), NDD (eight uniques), X-734 (seven uniques), or X-230J6

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(six uniques). A total of 12 SWMUs had unique COCs. It should also be noted that benchmarks could not be identified or developed for some of these unique COCs and, therefore, they could not be assessed for potential risk.

- Two SWMUs, NEDD (28 maximum values) and X-333 (20 maximum values) accounted for 32 percent (48 of 150) of the maximum detected levels for all COCs in all media combined (Tables 6.374 and 6.375).

- Among inorganic COCs, zinc had the greatest number of exceedences with 22 (combining all three media), followed by chromium and iron with 11, and arsenic with nine exceedences. Among organic COCs, benzo(a)anthracene had the greatest number of exceedences with 15, followed by benzo(a)pyrene with 14 exceedences. Acenaphthene, anthracene, and dibenz(a,h)anthracene all had the third highest number of exceedences with eight.

- Although magnitude of exceedence is not a deciding factor in the PERA analysis, it can provide information useful to a more detailed assessment, such as a BERA. Among inorganic COCs, the highest magnitudes of exceedence were for cyanide in sediment, cadmium in surface water, and iron in soil. Among organic COCs, the highest magnitudes of exceedence were for anthracene in sediment and 1,2,4-trichlorobenzene in soil.

Based on the PERA analysis, the following should be considered when determining the necessity for, and the scope of, more detailed analysis:

- A review of available data suggests that the terrestrial and aquatic habitats in Quadrant IV may support numerous types of wildlife indigenous to southcentral Ohio. A more intensive survey of the habitat in Quadrant IV would be needed to determine whether it can support the threatened and endangered species listed in Table 6.335 and Appendix H.9.

- Ninety-six of 213 potential comparisons between exposure estimates and screening benchmarks could not be made because benchmarks and/or toxicity data were unavailable. Information is needed to develop screening benchmarks for these chemicals and media as part of more detailed analysis (possibly using "surrogate compounds" with available toxicity data).

- There were many instances in which the maximum measured level of a particular inorganic COC was below its tentative soil background level but above the derived benchmark. The derivation and validity of these soil benchmarks, as well as that of the background analyses, need further examination.

- There are a number of instances where plant benchmarks are based on nutrient solution values because soil concentrations were not available. Soil benchmarks based on nutrient solutions are more conservative than those based on soil concentrations, and the uncertainty about these benchmarks is considered greater than about those based on soil concentrations.

- Fraction organic carbon data (Foc) in sediment were not available for use in the PERA. Therefore, a value of 4 percent was assumed based on Mackay et al. (1992). Because Foc is used to estimate sediment benchmarks, an assumed value of 4 percent organic carbon may either under or overestimate benchmark values

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for PORTS, depending on whether the actual Foc in PORTS sediment is lower or higher than that assumed here.

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7.0 CONCLUSIONS AND PROPOSED ADDITIONAL INVESTIGATION

The objectives of the RFI at PORTS, as listed in the OEPA Consent Decree and the U.S. EPA Consent Order, are enumerated in Section 1.0 (Introduction) of this report. Presented below is a discussion of how each of these objectives (shown in boldface below) were achieved during the RFI, including proposed additional investigation.

- ***Characterize the environmental setting, including groundwater, surface water and sediment, soil, and air***

As discussed in Section 2.0 (Characterization of Environmental Setting) of this report, the environmental settings of Quadrant IV and the PORTS facility are well understood as a result of this and previous investigations. In addition, background levels of naturally occurring constituents have been determined and are specified in the BSI (U.S. DOE, 1996a). Details of the Air RFI investigation are included in the Final Air Pathway RCRA Facility Investigation Report (U.S. DOE, 1996b).

- ***Define and characterize sources of contamination***

Potential sources of contamination were identified during development of the Quadrant IV DOCC (Geraghty & Miller, Inc., 1992a). Waste Characterization Data Sheets, which include detailed information regarding the physical and chemical properties of potential contaminants associated with these sources, were developed during the RFI and are included in this report. The nature of the operations, the structure, and the history of waste disposal at each unit were also reviewed to develop SWMU-specific scopes of work. During that review, point sources of potential contamination were identified at seven of the 27 SWMUs investigated. To complete source characterization of these SWMUs, sediment, surface-water, wastewater, or soil

samples were collected for comprehensive analyses. These seven SWMUs are as follows:

X-230J6 Northeast Holding Pond

X-230L North Holding Pond

X-342C Waste HF Neutralization Pit

X-344A Uranium Hexafluoride Sampling Facility/Settling Tank

X-344C HF Storage Facility/X-344D Neutralization Pit

X-611A Lime Sludge Lagoons

Chemical and Petroleum Containment Basins

Based upon the results of this sampling, the character of sediment, waste-water, surface-water or soil associated with all of these SWMUs has been well defined and no additional work is required to characterize sources of contamination at these SWMUs.

- ***Characterize the vertical and horizontal extent and degree of contamination of the environment***

As discussed in Section 4.0 (Technical Approach and Unit Investigations in Quadrant IV), contamination of environmental media was identified during this investigation at 13 of the 27 SWMUs in Quadrant IV. At all of these 13 SWMUs, the nature (constituents and maximum concentrations) and the vertical and horizontal extent of contamination has been determined and no additional RFI work is recommended in Quadrant IV to characterize the extent and/or degree of contamination. A groundwater radiological investigation was conducted in the Fall of 1994 as part of the RFI. Results of the site-wide Groundwater Radiological Investigation are presented in Volume 6 of the Quadrant IV RFI. Volume 6 will be

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submitted under separate cover and, upon agency approval, will be incorporated into the Quadrant IV RFI Final Report as Appendix I.

- ***Assess the risk to human health and the environment resulting from possible exposure to contaminants***

An evaluation of potential risks to human health associated with each SWMU in Quadrant IV was conducted as part of the RFI to support risk-based decisions regarding the need for further action. Risks were evaluated under two hypothetical future-use scenarios and the current-use scenario. Complete evaluations of soil and groundwater samples collected from areas adjacent to three SWMUs (RCW, SASW, and STSW) were not performed because of the spatial variation of data associated with these units. Data from these sampling locations were considered in the overall evaluation of the quadrant and in the evaluations of other SWMUs located near these SWMUs. Analysis of data collected during the RFI revealed no evidence of contamination that could be attributed directly to the RCW, SASW, or STSW.

The risk evaluation was performed using tentative background values for metals and naturally occurring radiological parameters. These values were calculated as part of the Quadrant I and Quadrant II Phase I RFIs. (Background concentrations of naturally occurring constituents must be established before risks can be fully evaluated.) Although these background levels have since been revised and characterized in the BSI, background values for soil and groundwater were not approved until after the assessment of risk for Quadrant IV SWMUs had been completed. Therefore, approved background values presented in the BSI are not incorporated into this report. In addition, inorganic constituents and naturally occurring radiological parameters were not evaluated in this report and will be assessed in the CAS/CMS. Risks associated with SWMUs in Quadrant IV will be assessed after background values are evaluated in the CAS/CMS. If this reevaluation of risk indicates that risk levels associated with a unit

are "acceptable," no further action will be proposed at that SWMU; if risk levels are "unacceptable," further action will be proposed. The results of the risk evaluation conducted during this investigation are summarized below.

Based on an analysis of risks associated with a hypothetical future-residential-use scenario a set of RME assumptions, SWMUs for which soil or groundwater data were collected can be separated into three groups classified according to potential carcinogenic and non-carcinogenic risk. Similarly, SWMUs for which surface water or sediment data were collected can be separated into risk categories based on a future-recreational-use scenario. Unless otherwise indicated, the following risk categorization is based on soil or groundwater data:

Target Risk Levels Not Exceeded

SWMUs in this group pose negligible carcinogenic risk (less than 10^{-6}) and negligible non-carcinogenic risk (hazard index [HI] less than 1) for the future-residential-use scenario. Four SWMUs are included in this group:

- X-114A Firing Range (X-114A)
- X-344A Uranium Hexafluoride Sampling Facility/Settling Tank (X-344A)
- X-745E Northwest International Process Gas Yard (X-745E)
- Old Northwest Firing Range (OFR)

Within Target Risk Levels

SWMUs in this group pose carcinogenic risks within the U.S. EPA range of concern (between 10^{-6} and 10^{-4}) for the future-residential-use scenario. Three SWMUs are included in this group:

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- X-334 Transformer Storage and Cleaning Building (X-334)
- X-611A North, Middle, and South Lime Sludge Lagoons (X-611A)
- Chemical and Petroleum Containment Basins East of X-533A (CPCB) and Emergency Containment Tanks (CPCB)

Target Risk Levels Exceeded

SWMUs in this group pose a significant carcinogenic risk (greater than 10^{-4}) or significant non-carcinogenic risk (HI greater than 1) for the future-residential-use scenario. Seventeen SWMUs are included in this group:

- X-230J6 Northeast Holding Pond, Monitoring Facility, and Secondary Oil Collection Basin (X-230J6)
- X-333 Process Building (X-333)
- X-342A Feed Vaporization and Fluorine Generation Building; X-342B Fluorine Storage Building; X-342C Waste HF Neutralization Pit (X-342)
- X-344C HF Storage Facility; X-344D HF Neutralization Pit (X-342)
- X-533A Switchyard; X-533B Switch House; X-533C Test and Repair Building; X-533D Oil House and Associated French Drains; X-533E Valve House; X-533F Valve House; X-533H Gas Reclaiming Cart Garage (X-533A)
- X-630-1 Recirculating Water Pump House; X-630-2A Cooling Tower; X-630-2B Cooling Tower; X-630-3 Acid Handling Station (X-630)
- X-734 Old Sanitary Landfill; X-734A Construction Spoils Landfill; X-734B Old Construction Spoils Landfill (X-734)
- X-735 Sanitary Landfill and X-735A Landfill Utility Building (X-735)
- X-744W Surplus and Salvage Warehouse (X-744W)
- X-745B Enrichment Process Gas Yard (X-745B)
- X-745F North Process Gas Stockpile Yard (X-745F)

- X-747H Northwest Surplus and Scrap Yard (X-747H) 2388
- X-752 Hazardous Waste Storage Facility (X-752)
- North Drainage Ditch (NDD); X-230L North Holding Pond; Construction Spoils Area (NDD)
- Northeast Drainage Ditch (NEDD)
- Railroad Spur Yard Storage Area (RSY)
- Transformer Cleaning/Storage Yard (TCP)

Based on an evaluation of sediment and surface water data under the future-recreation-use scenario, some SWMUs are included in different risk level groupings. The X-114A Firing Range Seep, the X-342C Waste HF Neutralization Pit, and the X-344D HF Neutralization Pit are within the target risk levels. The X-611A North, Middle, and South Lime Sludge Lagoon exceeded the target risk levels for the future-recreational-use scenario.

The criteria used to determine if sufficient data have been collected during the RFI to support the risk assessment are shown on Figure 4.2 and discussed in Section 4.2. Based upon a review using these criteria, sufficient data for the risk assessment have been collected to support the risk assessment at all SWMUs investigated.

- ***Support the CAS/CMS***

The results of the RFI provide a foundation for the Quadrant IV CAS/CMS which will be completed upon completion of the RFI. Data were collected during the Quadrant IV Phase I and Phase II RFI to characterize the nature and extent of contamination in environmental media, and to describe the environmental setting of the facility (including site geology/hydrogeology and groundwater flow directions). Geotechnical data including bulk density, particle density, grain-size analysis, soil

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permeability, Atterberg limits, standard Proctor analysis, soil porosity, cation exchange capacity, and total organic carbon were collected during the Quadrant I/Quadrant II Phase I/Phase II RFIs (Geraghty & Miller, Inc., 1992b, 1992c, 1994a, and 1994b, respectively). This combination of geologic/hydrogeologic and geotechnical data will be critical in the evaluation of corrective measure technologies that will be performed as part of the CAS/CMS. A preliminary evaluation of applicable or relevant and appropriate requirements (ARARs) for the PORTS facility was conducted in 1992 (Houlberg, et al, 1992). A complete review of ARARs will be conducted during the CAS/CMS.

Additional investigation was conducted at specific SWMUs to sufficiently define the area and/or volume of contaminated environmental media for the CAS/CMS. The locations and number of samples for this investigation were based on a data evaluation of the entire RFI analytical data set. Data collected to support the CAS/CMS is included in Appendix D2.

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